PRODUCTION MANAGEMENT TECHNIQUE.

Paper presented to the Institution, Coventry Section, by J. A. Hannay, Member of Council.

BEFORE I embark on a review of methods of controlling production as we know them to-day, I wish to stress to the utmost my view that the word "technique" does not and cannot at this stage of industrial development mean anything in the way of practice signed and sealed as the accepted thing. Even if that ever could be the case, I feel that production technique is, especially to-day, in a state of rapid flux, development and moulding, and that what we are doing now will appear comparatively feeble in but a few years. With that great reservation in mind I will endeavour to survey with you both field and practice as I see them.

We need go back in recollection but a few years to appreciate the great advance made in manufacturing methods in engineering and one small incident indicates what I mean. A little over thirty years ago I was visiting a Birmingham factory which was then engaged in cycle work. As we went through the shops, the managing director remarked, as he picked up a ceiling rose, "I used to make a good thing of manufacturing these: they sold for about 5s. 6d. each." To-day any of us would be glad to supply a dozen or twenty of them for that amount. That is typical of what we production engineers have all seen in the factories with which we have been associated.

To my question as to how much productive capacity had increased in his lifetime, a cost accountant of wide knowledge replied very definitely that from 1890 to the present day, general productive capacity had increased about 23 times. In the light of that statement it is obvious that within the past fifteen years we have entered an entirely new stage of engineering production, a stage of vastly bigger conception and one demanding an entirely new attitude towards analysis and control. We are forced to ask ourselves now regarding control methods:

(1) Have they advanced or improved?
(2) Are they keeping pace with the development of engineering equipment?

To the first question I would reply "slightly improved" and to the second, "no."

Though many offices are now equipped with the most ingenious machines for various phases of commercial accounting, I know of few cases where engineering production shops are provided with

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machines for progress control. I am convinced that we shall have to adopt machines extensively for the adequate survey, checking and analysis of all production activities, and I sometimes wonder what the production manager of the future will say of our technique to-day.

When increased output is called for, the production engineer of to-day does not immediately think of adding more machine tools to his plant, demanding more space and labour. Instead, he examines the extent to which the efficiency of the existing machines can be increased, or whether greater efficiency can be secured by machines of new design.

Some years ago I was operating a plant which after overhaul of the system was working like a new machine. A steadily increasing demand for output meant recruiting even more labour, and when I tried to visualise what requirements might be in a few years, I was staggered, not on the ground of expense, or any difficulty in getting labour, but at the simple problem of providing room for it. I had to face the problem, and at the first line of approach had to ask why, as we could produce machine tools, jigs, tools and fixtures, and much engineering equipment to help in our manufacturing problems, we did not apply mechanical methods in our control.

Mechanical Survey of Progressing.

I am going to tell you something of the efforts made to put such thoughts into shape and into practice, and for want of a better name I will call this practice mechanical progressing. One of the greatest defects in progress systems is the time occupied in preparing statements and reports: many are out of date and almost useless when received. I believe that we shall soon see considerable development and use of machines, automatic and semi-automatic, that will give us up-to-the-minute records and statements with which to start each day.

Leading off with the idea that all material, supplies, tools, and equipment should be ready and delivered without request to the operators, and their product removed when finished, all departmental managers, superintendents, and buyers should have statements and records regularly placed to their hands, and be under no obligation to keep records. What we want I might describe as a progress scoreboard, with means of transmitting the score to all who require it, including the department which must check production costs. The usual progress charts are frequently of local consequence only, and by the time their information has been collected at a central control point it has become stale.

While production is an important phase of any undertaking, do not let us imagine that it is the beginning and the end: let us keep it in due relation to other sections of the whole.

Policy.

I visualise in a modern organisation a chairman or managing director, or a committee of executive directors advising a board of directors and setting a policy. This must be followed by the

Fig. 1.

activities of: (1) a sales department with their knowledge and experience of the public's requirements; (2) a designing department to link policy and sales and interpret that policy in the form of schedules, plans, and drawings; (3) a production department which from schedules, plans, and drawings, carries the manufacturing processes through and delivers the finished product to the sales department; (4) a costing department.

I will now pass on to show you how production is allied to the other main groups in a car manufacturing organisation, and how control and management depend on whole-hearted co-operation with those groups.

After the board has sanctioned the manufacture of a certain number of cars, the sales department issue their car schedules, showing numbers and dates of required delivery. Then is issued the production chart (Fig. 2) which indicates when material, components, and complete cars must be ready. In other words, this graph shows the main departmental obligations:

Line 1—stamping material, bars and billets must be in the stores.

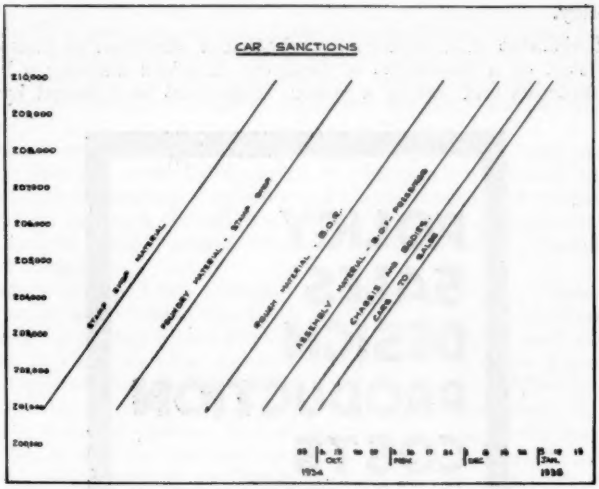


Fig. 2.

Line 2—foundry material must be delivered at the works, finished stampings must be received in the stores.

Line 3—all rough material, castings, stampings, sheet metal, etc., must be in the various machine shops.

Line 4—all assemblies must be ready, together with bought out and finished parts, etc.

Line 5—bodies and chassis must be ready.

These lines give a starting figure: if production has to be increased, or diminished, a fresh graph is plotted.

Control.

Production plans are laid out to deal in quantities—single parts, sets, components, chassis, bodies, and cars complete, and in various units of measurement, weight, count, etc. Finance requires everything in terms of £ s. d. Costs require both counts and £ s. d.

All departments and stores are numbered for production purposes and their numbers are so planned that they can be linked up with costs and finance. Movements in the shops are traced in £ s. d. by the use of a series of control numbers (see Fig. 3.) I am calling attention to this because co-operation between departments can save an organisation much needless expense.

The most important means of conveying information is undoubtedly by use of drawings. From Fig. 4 it will be noted that: (1) All limits are clearly marked; (2) material is specified;

(3) special notes are added. In some cases, when the drawings are complicated, extra and detailed operation drawings are made.

CONTROL NUMBERS

SOUTH WORKS

S.	LOCATION.	EXPENDITURE CLASSIFICATION						
		EXPENSE	CAPITAL	REVENUE			STORES STOCK	
				Payroll's	Non-Payroll's	Sales Expenses	Payroll's	Non-Payroll's
	Inspection No.3. View Room.	1500	1501	1502	1503	1504	1505	1506
	Inspection. South Dock Rough View.	1510	1511	1512	1513	1514	1515	1516
	Inspection.Stamp Shop View.	1520	1521	1522	1523	1524	1525	1526
	Inspection.Sheet Metal Insp:	1530	1531	1532	1533	1534	1535	1536
		1540	1541	1542	1543	1544	1545	1546
		1550	1551	1552	1553	1554	1555	1556
		1560	1561	1562	1563	1564	1565	1566
		1570	1571	1572	1573	1574	1575	1576
		1580	1581	1582	1583	1584	1585	1586
		1590	1591	1592	1893	1594	1595	1596
		1600	1601	1602	1603	1604	1605	1606
	Machine Shop No.1.	1610	1611	1612	1613	1614	1615	1616
	Machine Shop No.2.	1620	1621	1622	1623	1624	1625	1626
	Machine Shop No.3. (7. HP).	1630	1631	1632	1633	1634	1635	1636
	Machine Shop No.4(Gearchemiths)	1640	1641	1642	1643	1644	1645	1646
	Machine Shop No.5. (Erecting)	1650	1651	1652	1653	1654	1655	1656
	Machine Shop No.6. (Press Shop)	1660	1661	1662	1663	1664	1665	1666
	Main Tool Room.	1670	1671	1672	1673	1674	1675	1676
	Tool Room Dies.	1680	1681	1682	1683	1684	1685	1686
	Tool Room Press.	1690	1691	1692	1693	1694	1695	1696
		1700	1701	1702	1703	1704	1705	1706
		1710	1711	1712	1713	1714	1715	1716
	Planishing Section (Cowls)	1720	1721	1722	1723	1724	1725	1726
	Polishing and Plating.	1730	1731	1732	1733	1734	1735	1736
	Pickling Shop.	1740	1741	1742	1743	1744	1745	1746
	Parkerising Dept. (Fin.Stocks)	1750	1751	1752	1753	1754	1755	1756
	Pattern Shop. (South)	1760	1761	1762	1763	1764	1765	1766
	Packing Cases. (Making Section)	1770	1771	1772	1773	1774	1775	1776
		1780	1781	1782	1783	1784	1785	1786
	Road Test. 7.HP.	1790	1791	1792	1793	1794	1795	1796
	Road Test. Excepting 7. HP.	1800	1801	1802	1803	1804	1805	1806
	Radiator Shop.	1810	1811	1812	1813	1814	1815	1816
	Rectifications Engine (P. C.)	1820	1821	1822	1823	1824	1825	1826
		1830	1831	1832	1833	1834	1835	1836
		1840	1841	1842	1843	1844	1845	1846
		1850	1851	1852	1853	1854	1855	1856
		1860	1861	1862	1863	1864	1865	1866
		1870	1871	1872	1873	1874	1875	1876
		1880	1881	1882	1883	1884	1885	1886
	Stamp Shop.	1890	1891	1892	1893	1894	1895	1896
	Screen Shop.	1900	1901	1902	1903	1904	1905	1906
	Steering Section. 7. HP.	1910	1911	1912	1913	1914	1915	1916
	Saw Mill Shop. 7. HP.	1920	1921	1922	1923	1924	1925	1926
	Saw Mill Shop (General)	1930	1931	1932	1933	1934	1935	1936
	Spares Production.	1940	1941	1942	1943	1944	1945	1946
		1950	1951	1952	1953	1954	1955	1956
	Service Dept: Repairs Chassis.	1960	1961	1962	1963	1964	1965	1966
	Service Dept. Repairs Body.	1970	1971	1972	1973	1974	1975	1976
		1980	1981	1982	1983	1984	1985	1986
		1990	1991	1992	1993	1994	1995	1996

Fig. 3.

Let me direct your attention to the number of the drawing—1A3207, in the left-hand bottom corner. Anyone with the slightest knowledge of our drawing code numbers can tell from the number on a drawing to which model of car the part belongs. The symbol 1A denotes a seven h.p. chassis part, and as all numbers between 3,000

and 4,000 are allotted to gear boxes, the symbol 1A3207 is known to refer to a seven h.p. gear box part. The system I am describing

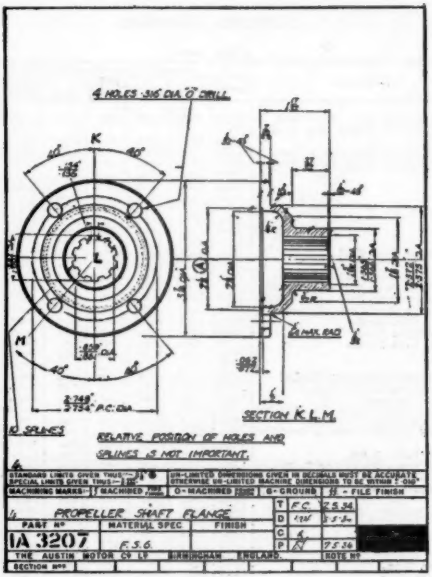


Fig. 4.

to-night depends very much on these drawing numbers as code numbers.

Construction of the Code.

The two chief requirements of a code are simplicity, with as few symbols as possible, and the certainty of covering everything imaginable that might be required. After many tests I concluded that the plan illustrated (Fig. 5) would easily hold good for many years. Out of the 1,000,000 code numbers provided 80,000 only have been allocated during the ten years the code has been in use.

Each square represents 10,000 numbers—0 to 9,999, so that one avoids having to use more than four figures. The squares are designated by prefixing a figure from the left and a letter from the top. The top left-hand square therefore will contain code numbers 0A0 to 0A9999.

The shaded squares, representing 310,000 code numbers, have been appropriated, and 25 per cent. of them are in use. The squares

ticked, representing 390,000 code numbers, have been reserved for designs and special departments. Blank squares, covering 300,000 numbers, are available as and when required.

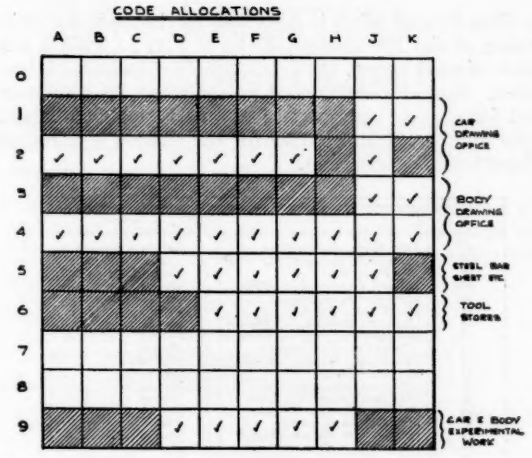


Fig. 5.

The shaded squares have been allocated as follows:

1A. 7 h.p. chassis.
1B. 12 h.p. 4-cylinder chassis.
1C. 20 h.p. 4-cylinder chassis.
1D. 20 h.p. 6-cylinder chassis.
1E. 16 h.p. 6-cylinder chassis.
1F. 12 h.p. 6-cylinder chassis.
1G. 10 h.p. chassis.
1H. 11.9 h.p. chassis.
2H. Electrical and special equipment.
2K. Nuts, bolts, washers, etc.
3A. 7 h.p. car body.
3B. 12 h.p. 4-cylinder car body.
3C. 20 h.p. 4-cylinder car body.
3D. 20 h.p. 6-cylinder car body.
3E. 16 h.p. 6-cylinder car body.
3F. 12 h.p. 6-cylinder car body.
3G. 10 h.p. car body.
3H. 11.9 h.p. car body.
5A. Steel bar, sheet metal, etc.
5B. Works engineers' material.
5C. Wood screws, rivets.
5K. Consumable stores material.
6A. Tool room.
6B. ,, ,,
6C. ,, ,,
6D. ,, ,,

9A.	Car and body experimental work.	9J.	Car and body experimental work.
9B.	" " "	9K.	" " "
9C.	" " "		

A page (Fig. 6) from what is described as the master code index, a book for each of the 100 squares shown in Fig. 5. This is a heavily bound book of good paper. As a code number is allotted it is entered in the index. Should a component be cancelled, its code number is never used for another component: the part replacing it is allotted a new code number. Index books for the shaded squares are held by the departments concerned.

Code No.		Description	Drawing Size	Specification
1A	1	Oil Pump Spindle Bush.	1.	Ex. Hard Bronze
1A	2	Camshaft Roller Race.	1.	HS 13.
1A	3	Oil Filler Cap.	1.	Sheet Aluminium.
1A	4	Filler Strainer Outer Gauze.	1.	Gauze
1A	5	Camshaft Rear Bearing.	1.	Hard Bronze.
1A	6	Oil Filler Cap Spring.	1.	MS 1.
1A	7	Camshaft Bearing Joint Washer.	1.	Paper
1A	8	Locating Ring for Timing Cover	1.	MS 1
1A	9	Timing Case Joint Washer.	1.	Paper.
1A	10	Oil Release Adjusting Screw.	1.	M.S. Bar
1A	11	Oil Filler Cap Spring.	1.	SH 54.
1A	12	Starting Handle Tube.	1.	Barss
1A	13	Nut for Cylinder Foot Stud.	1.	Forgut".
1A	14	Starting Handle Bracket	1.	N.C. 70.
1A	15	Valve Spring Cover Nut.	1.	Forgut".
1A	16	Water Inlet Branch Washer	1.	Rubber Insertion.
1A	17	Water Inlet Branch.	1.	Aluminium.
1A	18	Water Outlet Branch Washer.	1.	Rubber Insertion.
1A	19	Cylinder Head Joint Washer.	1.	Hard Copper, Wallsend.
1A	20	Crankcase Breather.	1	Rod Brass (Plain).
1A	21	Cylinder Head.	1.	C.I.
1A	22	Cylinder Foot Washer.	1.	Blackings No. 3.
1A	23	Intermediate Gear.	1.	Special C.I.
1A	24	Camshaft Gear.	1.	Special C.I.
1A	25	Intermediate Gear Pin.	1.	ST 40.
1A	26	Magneto Spindle Felt Plate.	1.	SH 50.
1A	27	Oil Pump Vane.	1.	HS 13.
1A	28	Main Bearing Housing Washer.	1.	Paper. Tally Records.
1A	29	Oil Pump Spindle.	1.	MS 13.
1A	30	Oil Pump Gear.	1.	MS. 13.
1A	31	Oil Pump Bottom Cover	1.	Hot Brass.
1A	32	Oil Pump Body.	1.	Hard Bronze.
1A	33	Joint Washer (Oil Pump).	1.	Vellumoid.
1A	34	Valve Split Cotter.	1.	FS 6.
1A	35	Valve Spring Cup.	1.	FS 6.
1A	36	Tappet Guide.	1.	Hard. Bronze.
1A	37	Tappet.	1.	A.S. 98.
1A	38	Tappet Screw.	1.	HS 13.
1A	39	Tappet Lock Nut.	1.	Forgut"
1A	40	Inlet Valve.	1.	EG.
1A	41	Exhaust Valve.	1.	Silicon Chrome.
1A	42	Piston Ring.	1.	Special C.I.
1A	43	Gudgeon Pin.	1.	N.S 13.
1A	44	Oil Barrel.	1.	SH. 50.
1A	45	T Bolt Swivel.	1.	MS. 1.
1A	46	Magneto Coupling Ring.	1.	Fibre Reinforced Rubber
1A	47	Magneto Stirrup T Bolt.	1.	MS. 2. Steel.
1A	48	Barrel Nut.	1.	MS. 1.
1A	49	Magneto Coupling Flange.	1.	Hot Brass. Steel.
1A	50	Joint Washer.	1.	Vellumoid.

Fig. 6.

Fig. 7 shows in detail how the numbers in the shaded square 1A have been allotted:

1A1 to 1A3,000—engine parts.
1A3,001 to 1A4,000—gear-box-parts.
1A4,001 to 1A5,000—front axle parts.
1A5,001 to 1A6,000—frame details.
1A6,001 to 1A7,000—steering parts.
1A7,001 to 1A8,000—rear axle parts.
1A8,001 to 1A9,000—wheels.
1A9,001 to 1A9,999—not allocated.

It is obvious that these code numbers readily convey to anyone using them an idea of the parts they represent (see Fig. 7). Shops and stores also have their code numbers.

Each of the sections has full details of its obligations for every model and must produce in accordance with the graph shown in Fig. 2. I referred to the graphs as departmental obligations.

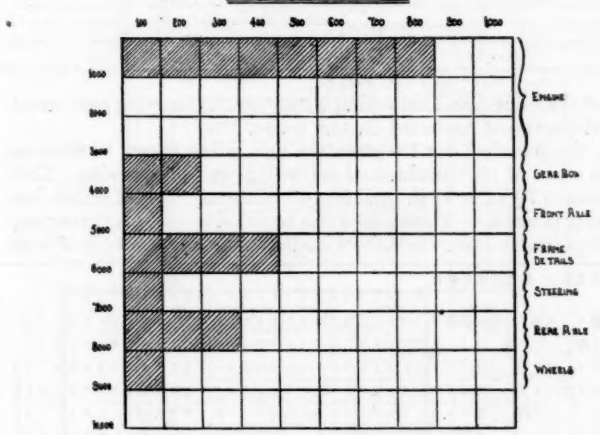


Fig. 7.

Routing.

We come now to the routing of details through the shops. Fig. 8 shows a route sheet. It is prepared by the production department immediately a drawing is received from the design department, and gives all particulars except those for the route column. It is submitted to the efficiency department (a section of the works engineer's office) who fill in particulars of the route. While material is being ordered and obtained, departments are advised of their

obligations. Planning and rate fixing (a section of the efficiency department) prepare a detailed layout. The drawing office is

THE AUSTIN MOTOR Co. LTD.

FROM PRODUCTION OFFICE TO EFFICIENCY. A/C L.C.5/6.

DATE 8th.September, 1934.

THE FOLLOWING PARTS ARE TO BE PREPARED FOR IMMEDIATE PRODUCTION AND ADDED TO THE VARIOUS CHARTS INDICATED IN ROUTE COLUMN 7 h.p. 1935 Season.

PART No.	DESCRIPTION	No. OFF	MATERIAL	FORM	TYPES USED ON	ROUTE	REPLACES	REMARKS
14.757.	Retaining Plate.	2.	S.M.Co.Class H	Press.	7 h.p.Low P.	SH.6.54.	14.583.	
14.758.	'8' Bolt for Petrol Tank.	2.	M.S.C.	Press.	7 h.p.Low P.	SH.6.54.	14.587	This alteration is to take place upon Chassis No. 202001.
14.759.	Petrol Filler Tube.	1.	Baldwins Genuine Spring Sheet Steel.	Press.	7 h.p.Low P.	SH.6.54.	14.580.	
14.760.	Inlet Valve.	4.	E.V.A.B.Spec.	Bar.	7 h.p. Low P.	Sa.8.3.7a.	14.69.	
14.761.	Exhaust Valve.	4.	Silicon Chrome Steel.		7 h.p. Low P.	Sa.8.3.7a.	14.70.	
14.762.	Valve Spring Cup.	8.	P.S.6	Bar.	7 h.p. Low P.	Sa.13.7a.	14.64.	
14.763.	Valve Cotter.	8.	Plain Bright H.T.Steel. 60/70 tons / sq.inch.			Sa.13.7a.	14.63.	

Fig. 8.

advised of the route, and they send a copy of the drawing concerned to each department included in the route.

Fig. 9, the punched card translation of a route sheet, introduces us to the start of our mechanical recording and progressing. This card measures $7\frac{3}{8}$ in. x $3\frac{1}{4}$ in. and has 45 columns, each of which has 12 punching positions. These cards can be ruled to give any grouping of the 45 columns into "fields" of coded information, which is both

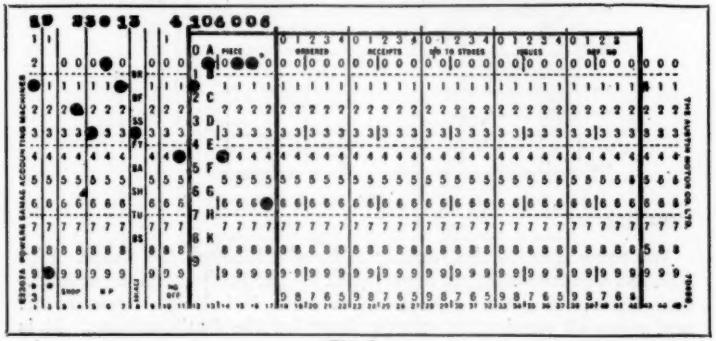
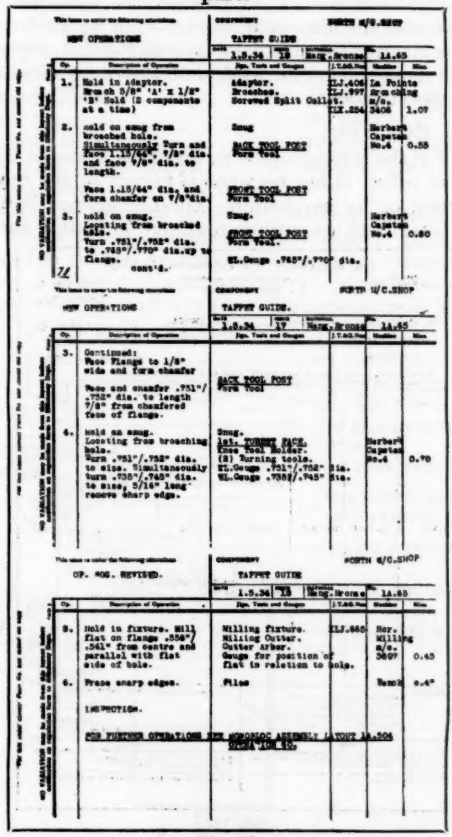


Fig. 9.

punched and printed in one operation. Each perforation registers a fact or part of a fact.

Column	1.	Day.	1st.
	2.	Month.	9th.
	4.	Shop No.	2.
	5, 6, 7.	h.p. of car.	301. (code)
	8.	Source of material.	Stamp Shop.
	11.	No. off per car.	4.
	12-17.	Code No. of part.	1A4006.


NEW OPERATIONS — COMPONENT: NORTH W/C.SHOP — TAPPET GUIDE — Date 1.8.34 — Type 18 — Material: Mang. Bronze — No. 1A.65

Op.	Description of Operation	Jigs, Tools and Gauges	T.&G.No.	Machine	Min.
1.	Hold in Adaptor. Broach 5/8" 'A' x 1/8" 'B' Hold (2 components at a time)	Adaptor. Broaches. Screwed Split Collet.	ILJ.406 ILJ.997 ILJ.224	La Pointe Arm oking m/c. 3408	1.07
2.	Hold on smag from broached hole. Simultaneously Turn and Face 1.15/64". 7/8" dia. and face 7/8" dia. to length. Face 1.15/64" dia. and form chamfer on 7/8"dia.	Smag. BACK TOOL POST Form Tool FRONT TOOL POST Form Tool		Herbert Capstan No.4	0.55
3.	Hold on smag. Locating from broached hole. Turn .751"/.752" dia. to .751"/.770" dia.up to flange. cont'd.	Smag. FRONT TOOL POST Form Tool. SL.Gauge .745"/.770" dia.		Herbert Capstan No.4	0.80

NEW OPERATIONS — COMPONENT: NORTH W/C.SHOP — TAPPET GUIDE. — Date 1.8.34 — Type 17 — Material: Mang. Bronze — No. 1A.65

Op.	Description of Operation	Jigs, Tools and Gauges	T.&G.No.	Machine	Min.
3.	Continued: Face Flange to 1/8" wide and form chamfer Face and chamfer .751"/.752" dia. to length 7/8" from chamfered face of flange.	BACK TOOL POST Form Tool			
4.	Hold on smag. Locating from broaching hole. Turn .751"/.752" dia. to size. Simultaneously turn .735"/.745" dia. to size, 5/16" long remove sharp edge.	Smag. 1st. SHOULDER FACE. Case Tool Holder. (2) Turning tools. SL.Gauge .751"/.752" dia. SL.Gauge .735"/.745" dia.		Herbert Capstan No.4	0.70

OP. 4OA. REVISED. — COMPONENT: NORTH W/C.SHOP — TAPPET GUIDE — Date 1.8.34 — Type 18 — Material: Mang. Bronze — No. 1A.65

Op.	Description of Operation	Jigs, Tools and Gauges	T.&G.No.	Machine	Min.
5.	Hold in fixture. Mill flat on flange .556"/.561" from centre and parallel with flat side of hole.	Milling fixture. Milling Cutter. Cutter Arbor. Gauge for position of flat in relation to hole.	ILJ.865	Hor. Milling m/c. 3609	0.45
6.	Frase sharp edges.	Files		Bench	0.4"

INSPECTION.

FOR FINISHED OPERATIONS SEE MORPHOLOC ASSEMBLY LAYOUT 1A.504 Sheet 4 to 10.

Fig. 10.

The jig and tool drawing office designs, and the tool room manufactures, the tools required to produce the work in the time stated.

These jigs and tools are not handed over for use in production until their sufficiency has been demonstrated to the shop superintendent's satisfaction.

The production of this card ensures that the superintendent, foreman, and progress man of the department—No. 2 machine shop—will receive in their next tabulation of the shop's progress full particulars of the material ordered for the particular parts. In handling a new job the efficiency department decides the method of operation, the machine tools to be used, the jigs and tools necessary, and specifies the time allowed for each operation. All this information is given in the efficiency layout (Fig. 10), copies of which are sent to all departments mentioned on the route sheet and to the tool room superintendent.

Buying and Receiving.

Authority for the buying office to purchase material comes from the production office, either by what is known as the buying chart of a shop order, or by requisition. The first-named is a complete schedule of parts with quantities required to enable the shops to

THE AUSTIN MOTOR COMPANY, LIMITED.

BIRMINGHAM.

ORDER NO.

TO Messrs. John Smith & Company, [3090] 1/1580 *

Dealer Street,

WARRINGTON, Lancs. 3rd. October 1934

Please supply, to conditions on back hereof, which must be strictly observed:—

QUANTITY	PART OR CODE NO.	CHARGE NO.	DESCRIPTION	PRICE
			CUMMINS CASTINGS	
			TO CONFORM TO 'AUSTIN' SPECN.GM.80	
2,000	14.3009	0845/03	Gearbox spoon Forks	@ per lb.
			Pattern and Core Boxes will be supplied by us.	
				4/6 free

REMARKS:— Sample by October 6th. Bulk deliveries, 500 per week commencing fourteen days after approval.

For the AUSTIN MOTOR COMPANY, LIMITED.

TERMS

NOTICE

1. This Order No. to be quoted on all Correspondence, Invoices, Advice Notes, etc.
2. Only one Order No. to appear on any one Invoice.
3. Invoices to be rendered IN TRIPLICATE.
4. Goods not to be consigned to Leyland Motors, L.M.&S.S., and G.W.R.
5. THIS ORDER MUST BE ACKNOWLEDGED BY RETURN POST

Fig. 11.

produce a definite number of cars. Requisition is used for new jobs, and alterations. Fig. 11 shows a specimen order placed by the

buying office with an outside supplier. The prefix 1. in the order number is the number of the buyer placing the order. The actual order number is one of a series of 10,000. For the purpose of mechanical accounting we have given code numbers to all our suppliers. In this case the supplier's number is 3890. The quantity and part number (2,000—1A3009) are given, with the control number of the stores where the material is to be delivered. Description and price follow. In the bottom left-hand corner we have the delivery instructions and along the bottom edge are our terms and routine notices. On the back of the order sheet are our conditions under which the order is placed.

Copies of the order are made for :

1. Buying Office.
2. Suppliers.
3. Control Office.
4. Receiving Department.
5. Urging Clerk.
6. Inspection Department.
7. Stores.
8. Invoice Checking.
9. Cost Office.

When goods are received they are checked against the buyer's order and advice note. As each advice note is passed, a Teleprinter operator in the reception department transmits to the buying office, a quarter of a mile away, the supplier's name, order number, code number, and quantity. Buyers are thus immediately informed of the reception of goods.

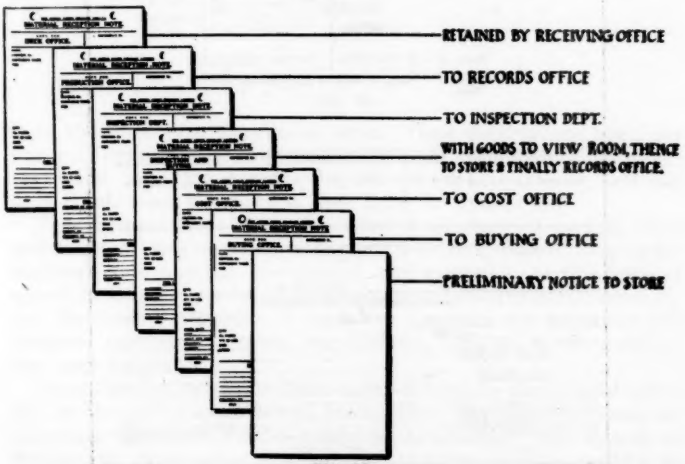

RETAINED BY RECEIVING OFFICE
TO RECORDS OFFICE
TO INSPECTION DEPT.
WITH GOODS TO VIEW ROOM, THENCE TO STORE & FINALLY RECORDS OFFICE.
TO COST OFFICE
TO BUYING OFFICE
PRELIMINARY NOTICE TO STORE

Fig. 12.

When the Teleprinter operator has transmitted the contents of the advice note, a reception note (Fig. 12) is typed from it. On a

duplicating machine six copies of this are run off and sent to: (1) Control Office; (2) Inspection Department; (3) accompanies Material; (4) Cost Office; (5) Buying Office; (6) Stores. Incidentally I may say that duplicating was found to be much better and cheaper than using carbon paper. In addition to the time taken in handling loose carbon paper, there was the disadvantage of getting indistinct copies.

The reception note deals with all pieces that have taken a definite form, have a code number, and can be counted. The note bears the name of the department concerned, a filing number, date, order number, shop order number, supplier's name and number, classification of delivery, description of material, quantity. A space at the bottom of the form is reserved for departmental notes.

Material that has to be worked into a different form such as pig iron, steel bars, billets, sheet metal, aluminium, copper, tin,

MATERIAL RECEPTION NOTE AND BOND CERTIFICATE.

COPY FOR DECK OFFICE

BOND Nº 6/844

Date 29/9/34. For Goods. 102633.

Order No. 5/7111. Buyer's No. 38.439/40.

Material Code No. 1981

Control No. 6065/02. Order

Shop Order No. 2626 etc. M.P. or S.O.

Supplier's No. 8419. Name M.F.Spencer.

Quantity 568. Unit of Quantity

Description

Sample.

No.1. A. A.B. B.D.Bts. Cast No. 1150. 1151.

Gross. 7 tons. 0 cwts. 2 qrs. 16 lbs.
Tare. 1 " 4 "

Particulars	Size	Length	Number	Tons	Cwts	Qrs	Lbs	Total Lbs
Short Bars Black Bars Billets	8½" x 3½"	x .036"		7	0	1	12	15720.

THIS STEEL WILL NOT REQUIRE HEAT TREATMENT TO MEET SPECIFICATION.

RECORDED BY

FOR USE OF INSPECTION DEPARTMENT ONLY.

Test No. 6850.

ACCEPTED / REJECTED AND TO BE RELEASED / RETURNED TO Cost Book.

DEFECTS Bad surface. do. Scratched. do.

THIS STEEL TO BE STAMPED AND PAINTED

INSPECTOR [signature] DATE 29th September 1934

Fig. 13.

ingots, etc., has a special reception note which takes the form of a "bond certificate" (Fig. 13). This class of material is held in

bond until the appropriate release has been issued from the laboratory.

Issue of Materials.

All material arrives at the store specified after it has been passed by the inspection department. Stores issue material to shops at programme rate and each batch of material issued is accompanied by a note from a Lamson Paragon register (Fig. 14). Four copies of this note are made on the register by means of carbon paper, which

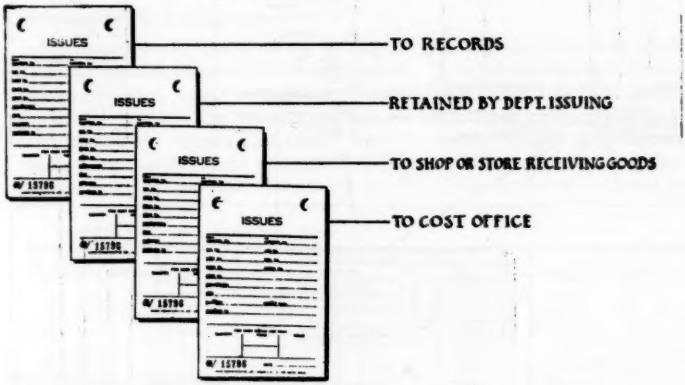


Fig. 14.

is in the form of a continuous strip. Their destinations are : (1) Control Office ; (2) Stores, retained in ; (3) accompanies Material ; (4) locked in box of register for use of cost accountants, and can only be obtained by them as they hold the master key.

The Paragon form bears the control numbers of issuing store and store or shop to which the goods are being issued, shop order number, code number, description, and quantity. As this form of note is in common use for all issues and transfers of material throughout the works, provision is made on the form for recording job number, operation number, specification number, bond number, size, and weight.

A continuous stream of these notes flows into the control office and at the end of each day all transactions have been reported for recording on punched cards ready for tabulating. This system of mechanical progressing enables the tightest possible control to be kept on stocks, as stock is taken virtually every day. When the factory closes for the night a small staff of clerks come on duty and proceed to tabulate mechanically all the movements of the

day. At 8 a.m. next day, executives have the whole position laid before them in the information given on the sheets printed by the tabulators.

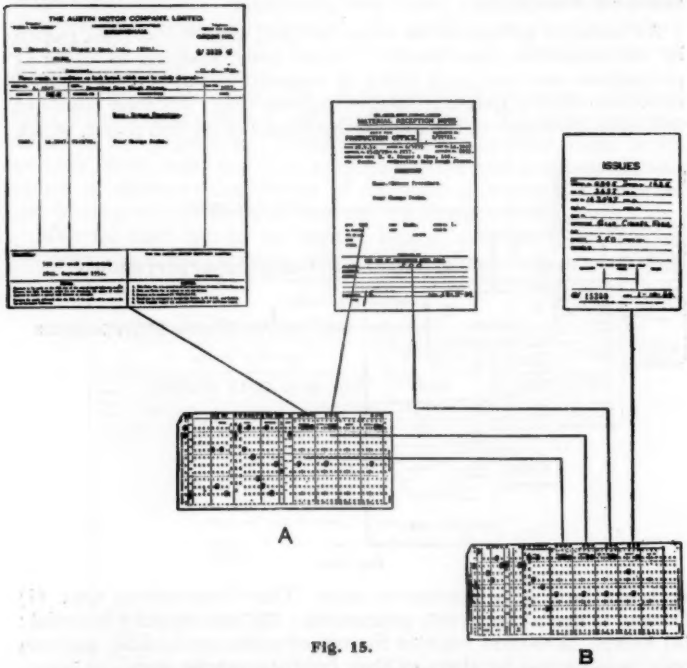


Fig. 15.

Illustrates the course of material. The first form is the order to supplier, and the second the form of receipts of material against that order. This information is punched into cards of type A, known as buyer's cards. Quantities are carried forward into cards of type B, which are also punched for issues as they are made by stores, using the third form. Tabulation of B cards, as shown in Fig. 16, constitutes a daily review of shop progress.

How the Cards Talk.

In Fig. 15 one can follow the usual course of a card, in this case the punched translation of a buying order, from its blank state till it adds its voice to the volume of information printed by the tabulators for analysis and guidance. To maintain a check on the accuracy of punching, it is repeated with a second set of holes elongating those first made. Any lack of agreement between the two operators is shown by the appearance of two circular holes. An ingenious machine separates cards so punched from the rest, and investigation follows. The next step in the use of the cards is to sort them upon

the code number which corresponds to the factor which is to form the focal point of analysis, in this case issues of material.

Having been sorted into numerical order in one particular field selected as a base for analysis of all the remaining fields of information punched on them, the cards go to the tabulating machine for automatic translation into typewritten characters. The machine adds and prints the totals of the quantities shown by cards as they are grouped in numerical order in the particular field under analysis. Also it automatically punches a card for each group, recording its total quantity.

Specimen Tabulations.

An example of tabulations which inform all concerned of their obligations and situation is shown below. To produce this tabulation the cards have been sorted on "issues" and the machine automatically prints the smaller quantities first, thus revealing shortcomings in the number of issues relative to the stages of ordering, receipt, and delivery to stores. Reading the tabulation, we see that the number of the last chassis for a particular model completed in

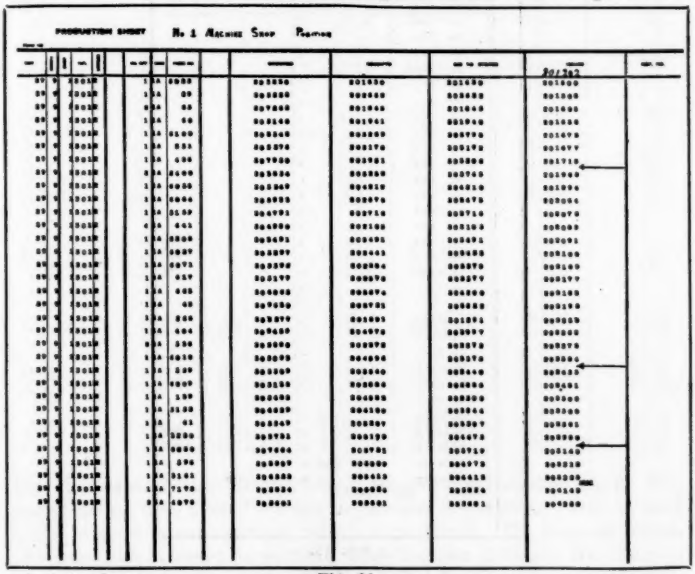


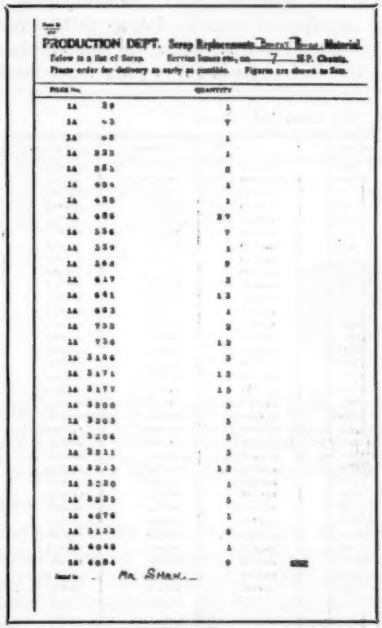
Fig. 16.

the week ending September 29th was 201,202, and the programme rate was say 600 cars per week. The tabulation shows that the supply

of the seven parts first-named is in danger : material must be issued straight away. The next 15 items are sufficient for one week only. Of the following six items there is sufficient material in the shops for two weeks. Supplies of the remaining parts are adequate.

As a complete set of tabulations is sent to all shops and stores they have no need to keep any records themselves.

All parts faulty or spoilt in the works are removed by inspectors so that they cannot by any means be used. A reject note is made out by an inspector when any material or work is faulty. These notes are sent to the chief inspector's office and a complete "reject" report is issued daily. A copy of the report is sent to the main production office, where it is examined. Any large items are picked out and orders issued for replacement of material. These are marked off the list, and the entire list is sent to the control office. Cards are punched for all these items and are allowed to accumulate for a



PRODUCTION DEPT. Scrap Replacements Project Issue Material

Below is a list of Scrap Service Issues etc., on 7 M.P. Charts.

Please order for delivery as early as possible. Figures are shown as Sets.

Piece No.	Quantity
2A 29	1
2A 43	7
2A 68	1
2A 233	1
2A 251	2
2A 404	1
2A 435	1
2A 486	27
2A 536	7
2A 559	1
2A 564	9
2A 617	2
2A 641	13
2A 663	1
2A 703	2
2A 736	12
2A 3156	3
2A 3171	13
2A 3177	15
2A 3200	3
2A 3203	3
2A 3206	3
2A 3211	3
2A 3213	13
2A 3230	1
2A 3231	5
2A 4076	1
2A 3133	8
2A 4048	1
2A 4084	9

Mr. Shaw...

Fig. 17.

period. They are then sorted and tabulated, and copies of the tabulation are sent to the buying office for replacement orders to be issued. See Fig. 17.

Scrap, of course, reduces the quantity available for the manufacture of cars. Therefore the chassis figures against the particular component must be reduced. To achieve this, details of scrap are punched into subtraction cards.

Block Signalling of Progress.

Every night a car progress and body tabulation (Fig. 18) is made, to show the location of all bodies in the line of progress at 5-30 p.m. The range of the tabulated statement is from body shop to stock, through seven stages at which the progress of bodies is checked.

A card is created for each body as it leaves the body shop. These cards are placed on the paint shop file. As a body moves into the trimming shop and mounting shop its card is extracted from one file, punched with the date, and placed on the next file in order of progress. When the body is mounted on a chassis the number of

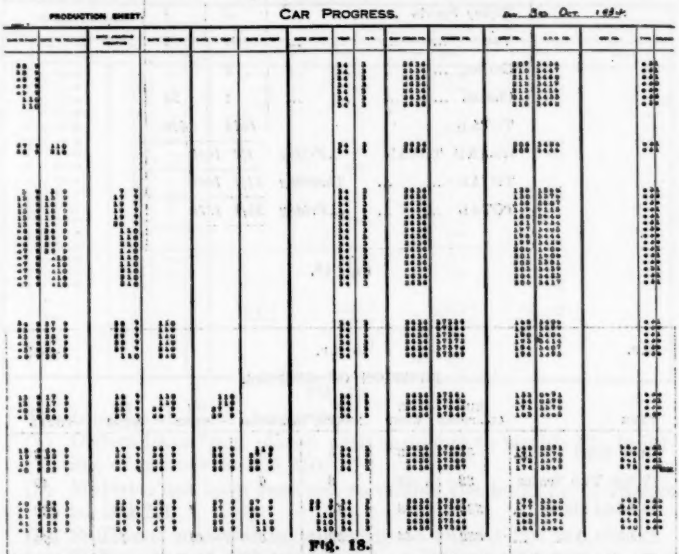


Fig. 18.

the chassis and date of mounting are punched on the card. The car is tested and passed by the inspection department, and at that stage is given a car number, which is punched. The date on which the sales department is advised that the car is ready for them is also punched on the card. With a tabulation of these cards it is easy to indicate the number of bodies in the various stages. Not only is the tabulation useful for progress review, but when the cards

are sorted into chassis number order a useful document can be produced from them for the service department.

From the tabulation shown in Fig. 18, all kinds of reports can be

W.P.

SUMMARY OF 10 h.p. SPO'S OUTSTANDING

	HOME	EXPORT
Open Road Tourer	16	37
Clifton Two Seater	24	16
Lichfield Std. Saloon	148	235
Lichfield D.L. Saloon	876	118
Cabriolet...	75	4
Ripley Sports	3	1
Van	66	5
Gordon	2	
Chassis	4	20
TOTAL	1214	436
GRAND TOTAL ...Friday	1/2	1650
TOTAL ... ... Thursday	31/1	1666
TOTAL ... ...Friday	25/1	1875

Fig. 19.

W.P. 10 H.P. 1-2-35

POSITION OF ORDERS.

TYPE	NOT ALLOTTED	ON WEST	ON SOUTH	MOUNTED	ON TEST	EX TEST	TOTAL
Open Road ...	38	2	5	8			53
Clifton Two Seater	22	10	2	6			40
Lichfield Std. ...	338	22	16		7		383
Lichfield D.L. ...	882	54	30	8	19	1	994
Cabriolet	16	26	21	7	7	2	79
Ripley Sports ...	1			3			4
Vans	15	44	2	2	8	2	73
TOTAL	1312	158	76	34	41	5	1626

Fig. 20.

made, enabling one readily to draw up progress statements, of which Figs. 19 and 20 are examples. From information flowing throughout the day to the control office the tabulation is produced during the night. In less than half an hour next morning progress information has been summarised in the styles shown. They give a complete picture of the position of one model.

At any time it is possible to follow, in tabulated form, the track of any component. Fig. 21 shows the movements by stages of a part bearing code No. 1A.16, from stocktaking in August, 1934 to week ending September 29th, 1934.

Line 1. The last chassis built, of a particular type, at August 4th.
Line 2. The quantity of material available at August 4th.
Line 3. The quantity of material outstanding with our suppliers.

Subsequent lines show movements of material ordered, received, delivered to stores, and issued from stores to shops.

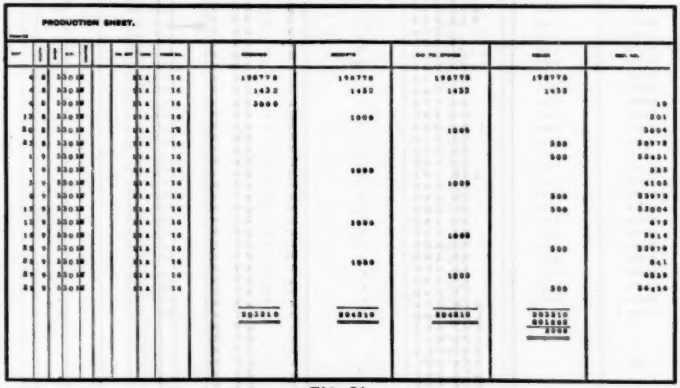


Fig. 21.

The total at the end shows that :

(1) Orders have been placed with suppliers to enable the building of chassis to 205,210.
(2) Material has been received to enable the building of chassis to 204,210.
(3) Sufficient material in stores up to chassis 204,210.
(4) Sufficient material in shops up to chassis 203,210.

The totals also show :

(1) By the difference between the first and second totals that there are 1,000 of this part yet to come from suppliers.
(2) There are no parts of this code number in the receiving department.
(3) Stores stock of this part is 1,000.

(4) As the last chassis built up to September 29th is number 201,202, the stock of this part in shops is sufficient for 2,008 further chassis.

Other Control Spheres.

Mechanical tabulation is almost without end in its applications. Fig. 22 shows a daily tabulation which places the number of railway

RAILWAY WAGON RECEIPTS.

WAGON No.	Co. No.	DATE
4 169	3	25 9
9 370	4	25 9
20 383	4	25 9
42 607	4	25 9
86 457	1	25 9
230 383	1	25 9
249 718	1	25 9
412 646	3	25 9 ←
236	3	26 9
6 127	3	26 9
11 246	4	26 9
27 925	1	26 9
34 753	3	26 9
36 761	3	26 9
45 772	1	26 9
65 360	1	26 9
81 086	2	26 9
90 410	2	26 9
96 351	2	26 9
98 708	2	26 9
120 391	2	26 9
15 946	2	27 9
20 669	2	27 9
22 280	3	27 9
30 565	3	27 9
31 152	4	27 9
44 609	2	27 9
45 145	2	27 9
46 644	1	27 9
49 395	1	27 9
78 810	3	27 9
110 826	4	27 9
110 980	4	27 9
143 862	1	27 9
198 643	1	27 9
242 440	1	27 9
244 227	1	27 9
274 240	1	27 9
324 553	1	27 9
327 440	1	27 9
428 171	3	27 9
709 241	4	27 9
11 214	1	28 9
15 300	2	28 9
18 202	2	28 9
20 068	3	28 9
21 181	4	28 9
22 945	2	28 9
24 644	2	28 9
29 163	1	28 9
29 641	4	28 9
42 729	1	28 9
55 524	1	28 9
71 501	3	28 9
96 297	3	28 9
100 092	1	28 9
102 047	1	28 9
102 630	2	28 9

Fig. 22.

trucks in the date order of arrival. The tabulation is made from the siding file every day and sent to the railway foreman, who can

see from it which wagons are liable to demurrage. This simple tabulation has saved the company much money.

Fig. 23 shows a tabulation of all consumable material issued to the press shop in a given period. Materials such as glue, solder, emery cloth, packing material, brooms, brushes, oils, greases, and practically everything used in manufacturing a car that would not be described in the ordinary way as an engineering tool are grouped in the consumable stores. The bulk of the material is held in the

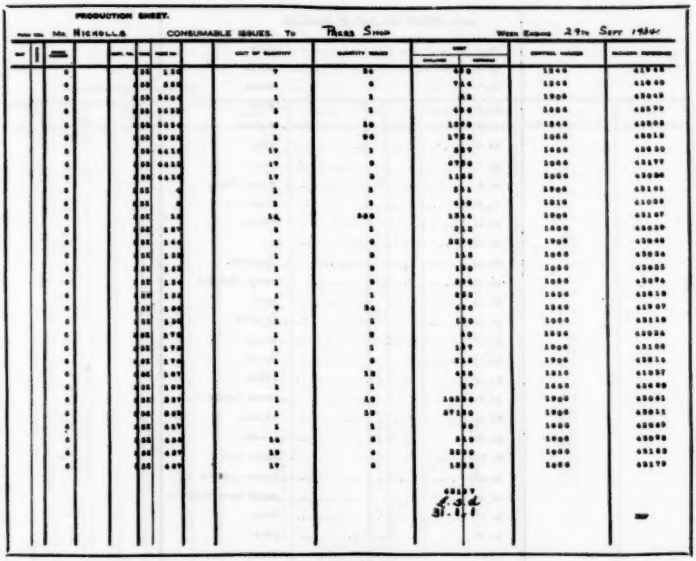


Fig. 23.

main stores, while eleven sub-stores are situated at convenient points. When a Paragon note is made out for the issue of material its price is included. The quantity units vary with the material. Fig. 24 shows how these units are coded.

Some very useful effects have been secured since the control office took charge of the accounts of the consumable stores. As some of the results we have (1) been able to send to shop superintendents every Monday morning a statement (Fig. 23) of quantities and cost of materials issued to their shop in the previous week; (2) kept a tight hold on stocks by maintaining an up-to-date return of all receipts and issues; (3) reduced the percentage value of our

consumable material per car, a very important point; (4) been able to hold smaller stocks, effecting a saving of capital; (5) been able to place bulk orders with suppliers to be delivered over a period on specified dates, our figures indicating the rate of consumption.

In stocktaking the punched card system is invaluable, and for the purpose of stocktaking the works are divided into 350 sections.

CODE NUMBERS FOR UNIT OF QUANTITY.

No. 1	Each.
No. 2	Dozen.
No. 3	Gross.
No. 4	Pint.
No. 5	Gallon.
No. 6	Foot.
No. 7	Yard.
No. 8	Square Foot.
No. 9	Square Yard.
No. 11	Quires.
No. 12	
No. 13	Standard.
No. 14	Pound. (Weight)
No. 15	Sets.
No. 16	Lengths.
No. 17	Rolls.
No. 18	Pairs.
No. 19	Pieces
No. 21	Reams (Paper)
No. 22	Inches.
No. 23	Ounces.
No. 24	Cubic Foot.
No. 25	Square Inches.
No. 26	Board Foot (Timber)
No. 37	Tons.
No. 38	Cwts.
No. 39	Thousands.

Fig. 24.

In each section there are a number of batches. The material in a batch is of the same part number, and at precisely the same operation stage of manufacture. At our stocktaking in August, 1934, 80,000 of these cards were punched and tabulated. The works were closed for one week while stocktaking was in progress. On the re-opening day all progress men received their stock figures, and four days afterwards the complete new works' stock ledgers, totalling 3,500 pages, of which Fig. 25 is an example, were ready.

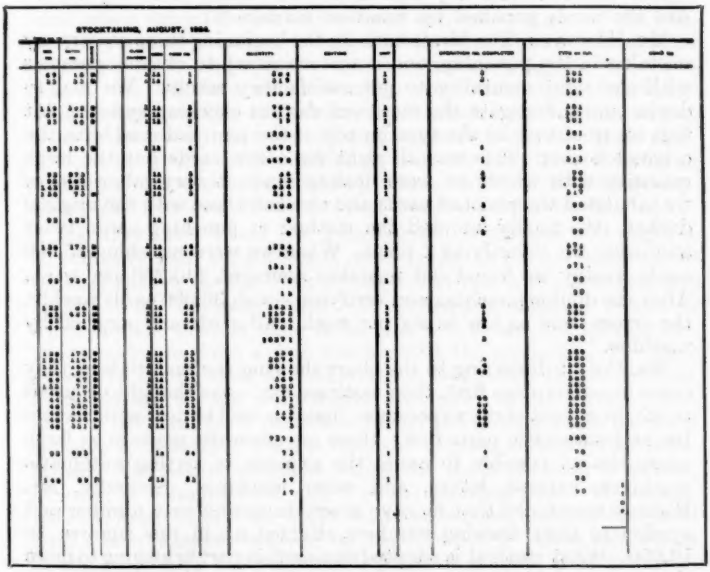


Fig. 25.

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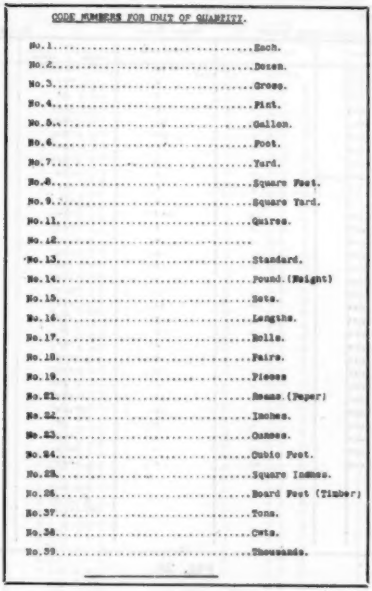

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No. 11	Quires.
No. 12	
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No. 14	Pound. (Weight)
No. 15	Sets.
No. 16	Lengths.
No. 17	Rolls.
No. 18	Pairs.
No. 19	Pieces
No. 21	Reams (Paper)
No. 22	Inches.
No. 23	Cases.
No. 24	Cubic Foot.
No. 25	Square Inches.
No. 26	Board Foot (Timber)
No. 27	Tons.
No. 28	Cwts.
No. 29	Thousands.

Fig. 24.

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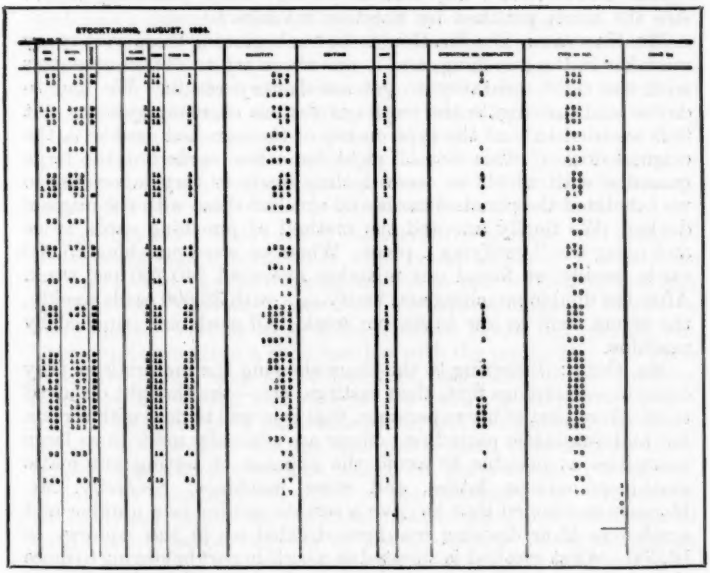


Fig. 25.

Discussion.

MR. G. HEY (Section President, who presided): We have had a most enjoyable lecture. The subject has been taken right from the designs office to the completed stage. Before saying very much about it I would like any gentleman in the audience to ask questions or make any criticisms, and Mr. Hannay will be pleased to deal with points raised.

MR. GOULD: Are any mistakes made when punching cards? Are the cards punched by hand or machine?

MR. HANNAY: Yes, Mr. Gould. In the beginning there were many mistakes in the punching, and it was necessary to obtain operators with the right mentality to get satisfactory results. We had to devise and investigate the merits of various checking systems. At first we tried to read the type on top of the punched card with the original docket. This was all right for a few cards but the large quantity with which we were dealing made it very laborious, so we tabulated the punched cards and checked these with the original docket. We finally adopted the method of punching cards twice and using the "verifying" plant. When we were punching 25,000 cards weekly we found our mistakes averaged 240-250 per week. After the double punching and verifying—with 35,000 cards weekly, the errors were as low as six per week. All cards are punched by machine.

MR. COLE: Referring to the chart showing the materials as they come in—stampings first, then castings, etc.—the thought occurred to me, from part of my experience, that it is well to deal with certain bar and automatic parts first; these are generally made in as large quantities as possible to avoid the expense of setting automatic machines, capstan lathes, and other machines. Secondly, Mr. Hannay mentioned that he gave a certain symbol or a number and symbol to their drawing numbers, divided up in the squares to 10,000. What method is adopted on a certain part belonging to more than one model? How do you account for a great number of parts which are common to, say, both the 12 h.p. four cylinder and 12 h.p. six cylinder models? How do you deal with this from the drawing office point of view. Time saving devices. Have the Austin Motor Co. any way of defining hardening operations, i.e., any symbol or series of numbers whereby when the hardening department get work passing through they can immediately refer to a chart which tells them what particular treatment that part has to have. Referring to the chart of the engine. Eight hundred was mentioned as the number of parts that had been numbered

for the seven h.p. engine, i.e., new parts, altered parts, etc. I was wondering if some other cross section could not have been put on the chart to show how many were obsolete, etc. Operation sheets. I noticed on the operation sheets that amongst other particulars were certain times—one minute five seconds—does that mean the floor to floor time for each part? The slide showing sample order sheet issued by your purchasing departments calls for 2,000 pieces, but I see no reference made to the quantity required per week. It has been my experience to deal with ordering of materials in various ways, one being to place an open order with the suppliers and then a schedule for the material through the production department. There was a chart shown giving the value of consumables. I thought that was a splendid idea because you can see at a glance the individual value of the various consumables which are shown on that chart per week, and also the total amount showing the value as a whole. On the first chart mention was made of the board and various departments, the costing department last. I think, talking from plant costs, that the costing department should come first. I think the policy is determined by the cost per lb. or the cost at which you can make the finished product, and then the sales department after the cost of the product has been determined.

MR. HANNAY: Chart No. 2 has served its purpose well and was shown only as a suggestion of what could be done. It should be an easy matter for Mr. Cole or anyone to plot a chart to suit any organisation. Common parts. We have parts common to two or more models, such as nuts, bolts, washers, studs, coil springs, etc. These parts are given a code number with the prefix 2K. The more expensive items, such as carburettors, ball races, thrust washers, dynamos, and similar components, are known as 2H parts. A part may be designed for a particular model and subsequently be found suitable for another. In this case the original code number is retained. The actual model on which the parts are used is quoted, in code, in columns 5, 6, and 7 of the punched card. Treatment. All steel received into the works has to be bonded, and is not released until a bond number is given by the laboratory. When submitting to the laboratory the purpose for which it is to be used is stated. If treatment is necessary the laboratory issue a card quoting the treatment number and this is sent with the material to the heat treatment department where there are full details of all treatments. Obsolete parts. We do not know how long parts may remain obsolete. A part may be cancelled and then reinstated. Once a code number has been allotted to a particular piece, that number is never used again. If a piece is cancelled by some modification or change in design, a new number is given. We have no chart showing obsolete parts. We have, however, an index card for every piece. Following our annual stocktaking, the 800 parts referred to are divided

into two lots—current and obsolete. The cards for those in current production are placed on a file for easy reference. Operation sheets. Yes, the time allowed is from floor to floor. This time has to be carefully borne in mind by the jig and tool designers, tool makers, and demonstrators. Should an operator be unable to produce a part in the time stated the shop superintendent will call upon the tool department to actually demonstrate the job. Deliveries. On the bottom left hand side of the order sheet there is a note: October 6th for delivery of sample—bulk deliveries of 500 per week commencing fourteen days after approval. Policy and costs. When referring to Fig. 1, I mentioned that costs, although last, were not least. Estimating plays a big part in an organisation. It assists designs and sales and helps in the formation of policy. Production handles facts and must produce and deliver goods to programme.

MR. COULTON: Mr. Hannay mentioned that prior to stocktaking the issue of material to the shops was restricted so that stock might appear in stores as components or assemblies. After stocktaking, what are the last operation men doing? By the adoption of this policy I should imagine that the operations are so small in number that there is very little waiting time. I should like to know the longest time taken in getting material from the first to the last operation.

MR. HANNAY: I made a plan showing the ideal lines (Fig. 2). Unfortunately, our customers will not be controlled by plans. Our stockrooms, which hold a week's output, cover an area of ten acres. At times we have to stop manufacture. The longest time taken for a component to go through all operations is two days. After stocktaking it would take two days to get the gear box or crankcase sections working. The last operation men would be told when to report back to work.

MR. CHAIRMAN: We have had a very interesting lecture and one thing that struck me and which I expected someone to ask questions about, was regarding the machines for punching and tabulating the various cards and the processes they go through. I think the foundation of the system is the arrangement of code numbers. The punching and tabulating machines can only operate by numbers and not by typewritten words. Some four years ago I was at a lecture in London given by the Tabulating Corporation, and we had a demonstration but the machines were too large for general use—seven or eight feet long. It might be interesting to get a description of the machines. I am surprised with regard to stocktaking that the whole thing could take place in two or three days.

On the motion of Mr. Cole a hearty vote of thanks to Mr. Hannay was adopted.

PRODUCTION MANAGEMENT TECHNIQUE.

Discussion, Western Section, opened by J. T. Kenworthy, M.I.P.E.

MR. KENWORTHY: In introducing the subject of production management technique, it would perhaps be best to make a short survey of the recent progress of manufacturing conditions. Immediately prior to the war intensive or mass production was very little in evidence in this country, the manufacture of sewing machines and ball and roller bearings being among the exceptions in the engineering trade. The advent of the war caused an unprecedented demand for munitions of various kinds and the manner in which the country responded is well known. The extraordinary conditions existing immediately after the war called for profound consideration and the knowledge derived during the war period was invaluable when peace conditions were resumed. Prior to the war the motor car had been mainly considered as a rich man's toy but its real value had by now been established and this was a sphere which best lent itself to intensive production, and every credit is due to this branch of industry for the progress made. Other sections of industry have also developed intensively when the nature of the product and its possible requirements have permitted.

The demand for any commodity is mainly controlled by its utility and its market price and these features are the results of the combined efforts of the designer and the production manager. It is the fundamental principles employed by the production manager which we are called upon to consider this evening. In the first place the production manager himself should have technical ability and some knowledge of accountancy. He should also have an analytical mind, directional ability, and be to some extent a psychologist. His personality should be such that he will inspire the confidence of those who come into immediate contact with him. These characteristics should also prevail amongst those members of his staff who are immediately responsible to him and they should also exercise tolerance towards their fellow-members of the staff. Those members of the staff dealing directly with labour should also be sympathetic but exacting in dealing with labour.

Before the production manager can commence his organisation, he must get the requisite information regarding the product to be manufactured from the design office. The designer has no doubt made the production manager what he is from a production standpoint as apart from administration. Day by day, he puts more

Bristol, October 19th, 1934.

intricate designs forward, the production of which at economic prices, calls for profound consideration and represents the fodder on which the production manager thrives. However, in many instances, he presents it in such a manner that the information is incomplete or will prove too costly to manufacture. During the design stage some sort of liaison should exist between the design and production departments as much can be done in the nature of small modifications to reduce manufacturing costs and it is a very desirable condition that a design should not be introduced for manufacturing purposes until it has been made experimentally and suitably modified to ensure the most economical production.

Much can be done at this stage to assist production by attention to the information given on detail drawings. All dimensions should be well defined and limits of manufacture of a recognised system whether unilateral or bilateral should be clearly stated. These limits should be as wide as possible according to the nature of the design in order to give the greatest possible scope to the production departments, and should have been verified during the experimental stages. Particulars of the material specification should be shown and details of any heat-treatment or protective treatment which may be required. These drawings cannot be too clear or too complete. The design office must also prepare and issue a specification of the parts comprising an assembly and the quantities required and the amount of material required to produce each component when these are produced from bar material should be determined.

One of the most essential requirements of efficient and economical manufacture is continuity of production and any change of design should only be introduced at pre-determined periods, allowing time to obtain new supplies of material, design and manufacture new jigs and tools and so ensure an even flow of the new material.

Before actual manufacture is considered, it is necessary to estimate the production costs and in this respect much information can be obtained during the experimental or try-out stages having regard to the free-hand conditions existing at this period. The estimates must, of course, make allowance for the overhead charges, these being in the case of an established firm already known, although some adjustment may be necessary if new plant is required.

The type of plant to be used and its layout must now be considered. In most cases plant will already exist which must be utilised unless considerable saving can be shown by the purchase of new plant or the special adaptation of existing plant. Should the quantities required merit it, a new layout should be considered if this will ensure a more even production flow and reduce transport. In order to ascertain this layout, a detailed process for each component will have to be determined and the time allowed for each operation stated. In the event of line production being considered,

the operations should be arranged to a time factor. The master process should be explicit in regard to detail as the information thereon is a definite instruction to those engaged on actual production.

At the same time the necessary jigs and tools should be designed and ordered. The extent to which jigging can be carried out will be indicated by the quantities required. It is desirable wherever possible to issue stage drawings of each component which should clearly denote the jigs, tools, and gauges for each operation. Again where quantities permit, these should be kept together and readily accessible. The jigging and tooling will be carried out in accordance with the pre-determined sequence of operations through which each component will pass. The closest co-operation between the process department and the jig and tool design office is most essential at this stage.

In the meantime it is necessary to order the required materials. Not many establishments are so placed that they can manufacture all the parts required to complete a design and it should be determined which parts should be bought finished and which are to be purchased as raw material or semi-finished. This information is passed on to the purchase department which should be under the control of the production manager. Material will be ordered for delivery in rotation to ensure the minimum tie-up of capital but yet maintain a steady flow through the shops. It is not always a good policy to buy materials in the cheapest market, as the machinability of bar steels in particular will quickly upset the best of estimates whilst a series of faulty castings found at a late stage of machining are even more serious, as in addition to considerably increasing the cost of production they cause delay and so hold up other work which may be in an advanced stage of production. All material as received will require to be inspected to an implied standard and such tests as are considered necessary carried out before being forwarded to a raw material stores.

Having received the material some system is necessary whereby this can be issued to the shops to ensure that it is machined in the correct sequence, and records kept of the progress of the work at any time. This material will be requisitioned by the planning department for each batch of components in such a manner that the costing department can ultimately link up the issue of the raw material with the manufacturing costs. Each batch of components must be accompanied by some means of identification so that as each operation is carried out, whether the operator is working on some recognised bonus system or on day rate, a record of the cost can be made and forwarded to the costing department. During the machining process of components, a system of inspection should be introduced. The amount of inspection required will depend on

the nature of the operation and the manufacturing system in use.

When the machining operations are completed, or it might be more accurate to say when each batch of components is completed ready for assembly, these should be passed into a finished part stores and the records accompanying their manufacture forwarded to the cost office in order that the costs may be ascertained.

Records will have to be kept of the progress of parts during machining in order to ensure that the parts necessary to complete any particular assembly shall be completed at the same time as near as possible. The progressing of parts through the shops is a very essential feature of production and many methods are in existence. It is doubtful if any one system could be applied successfully in its entirety in more than a few establishments. The system employed must take into due consideration the nature of the product and the layout of the plant. The more automatic a system can be made, the more successful it will be in operation. This is borne out by the fact that on line production little or no progressing of work is required. As all operations are split up to a time factor, the work must proceed automatically down the production line, or failure becomes inevitable.

When each batch of work is issued it represents some part of an assembly and a record should be kept of this issue and the machines on which the work will be carried out, and the time to be taken. Reference should be made to the progress of the work from time to time in relation to the records to confirm that the work is proceeding according to schedule. It is essential that the various parts being machined should be completed at the same time as nearly as possible, so that the least possible amount of capital is lying dormant.

At this stage the parts which have been manufactured will require to be issued or transferred to assembly. The parts comprising an assembly are shown in the specification issued by the design department and from this information the planning department should draw up some form of requisition on which the parts are issued from the stores, the requisition being forwarded from the stores to the cost office. A process of assembly should be determined and a method of identification issued with each batch against which the time expended on assembly should be recorded. The periods at which inspection should take place should be denoted and a signature obtained from the inspection department when the work is completed and accepted to a recognised standard, and the identification dockets should then be forwarded to the cost department.

In the event of any tests being required after assembly, these should be carried out to an approved standard and the completed unit passed to the dispatch stores and the sales department notified.

The next feature for our consideration is the application of the

principles briefly outlined. It will be generally accepted that the smaller and less intricate a part to be manufactured and the larger the quantity required, the simpler will be the system adopted. These conditions admirably lend themselves to intensive line production. Under these conditions the direct labour employed will probably be semi-skilled but the controlling staff highly qualified in technical administrative ability.

At the other end of the scale, there are the conditions where only one off per article is to be made or the numbers are never very large and the parts are in some cases very intricate, the types of product to be manufactured varying considerably. Under these conditions the planning is very difficult and in many cases the cost of jigs and tools prohibitive. In such cases the direct labour employed will need to be highly skilled.

Somewhere between these two extremes lie those conditions existing in most establishments to-day. Under the former the overhead or administrative costs will be exceptionally high in relation to production costs and under the latter their relation will be still higher but to a much lesser extent. Where the product and the quantities permit line production should be installed and there is no doubt that these conditions best offer themselves for the greatest efficiency in production.

This does not, of course, mean that the task of the administration is simple. Even when the organisation is in full swing and producing a product at a marketable figure, there is the future to consider and each operation must be analysed in turn to see whether the methods can be improved and the cost reduced. In addition new designs are continually being produced and at periods a complete change over to designs superseding those in existence may be necessary.

Those organisations which cannot wholly produce their products on the line system can with considerable saving in many cases adopt this system in a partial sense. The continuity of production which is an essential feature of this system contributes largely to its greater efficiency. Whatever system is adopted should have as a basis simplicity. Too much paper work and too many forms lying about cause a great deal of confusion in addition to wasting a large amount of time.

The efficiency of an organisation depends very largely on the conditions under which direct labour is employed. In order that the best efforts be put forward every effort should be made to enable them to carry out their work without interruption. Prices when once set should be unchanged and every incentive given to the operator to get an increased output. Although this may result in large earnings, it has the ultimate effect of a reduction in costs as the overhead

charges will be reduced in proportion to the reduction in time taken to complete an operation, and this item is considerably greater than the labour cost. The chief concern of labour to-day, perhaps naturally, is its earnings, and if these are adequate yet fair, a contented shop will be the result and any other condition is inimical to economical production.

Before concluding, there are two features to which reference should be made which play an important part in costs and which present each in turn a difficult problem for the production manager. The first of these is transport. How often does one see a really efficient system of transport apart from line production. This is a problem worthy of consideration and might be considered in two ways: (1) consider how to reduce the necessity of transport; (2) produce more efficient means of transportation. The other feature which if its cost could be computed, would no doubt provide staggering results, is waste. Waste can be roughly divided into two sections—material and time. Waste of material may include parts which are scrapped and the cost of which can be readily computed, but in addition misuse of tools and equipment causing rapid deterioration and losses of parts and equipment would nominally come under this heading. Waste of time is not prevalent by those on direct production as payment by results in some recognised form mitigates against this, but undoubtedly a great deal of time is wasted by those whose quota towards production cannot be accurately gauged.

In my short survey of our subject I have in mind the normal engineering type of works as the majority of us are more familiar with that type of organisation. The fundamentals involved whatever the type of production should be the same and these are briefly: (1) Intelligent application of existing plant and capital; (2) accurate estimating of manufacturing costs; (3) provision of the most suitable raw material for the work in hand; (4) provision of adequate and efficient equipment commensurate with the quantities required; (5) accurate forecasting of material movement during manufacture; (6) the compilation of reliable manufacturing costs; and (7) the intelligent application of these principles by the administration. Finally, I would again emphasize the necessity for complete harmony not only amongst the staff members of the organisation but also between the staff and operators.

MR. WHITEHEAD: In the first place I must congratulate Mr. Kenworthy on the admirable way in which he has approached the subject-matter of his paper. It is a tantalizing subject to discuss; it is one of those very easy to talk about for a long time, and by the time you have finished you have said nothing really concrete. I think that instead of "Production Management Technique," "Production Management Experience" would have been better.

With regard to the question raised by the Council as to whether the Institution can formulate a set of fundamentals or principles which will govern this subject of Production Management Technique, I, personally, do not think this possible. Mr. Kenworthy outlined an ideal technique, but I think every works has to formulate its own, and that a different technique is applicable in every case. I suggest that it is impossible to lay down any set of fundamentals which will apply universally. From my experience as a production manager I would say that Mr. Kenworthy has outlined a system which looks quite sound on paper, but if you take any of the detail points, you can immediately put "spokes" in all his arguments, as to why they will work in one case and not in another. It is easy enough to imagine components flowing through the shops and going through the different departments, being inspected and checked, until you arrive at the finished article on schedule, being also O.K. for price, but in practice one finds things do not always work out like that, there are other departments outside the Production Manager's control, which can step in and with the best intentions in the world can absolutely tie up, temporarily, all your ideal organisation. In cases like that production management experience alone comes to the rescue.

Mr. Williams: Mr. Kenworthy has given us a very good opening. He started off by giving the qualifications necessary in a production engineer and described the various departments and operations over which he exercises control. These are so exacting and comprehensive that any production engineer present who has any claims to being at all successful must of necessity blush with manly modesty. One little point I hoped to hear him touch on and that is the provision of a chart for the guidance of the shops foreman giving the potential hours to be worked on any given order in his particular section. We know there is a certain amount of work necessary in order to produce a certain job. Now this can be divided in to the various sections the job has to pass through, and the figures used as a guidance to the various shops foremen. I think this point ought not to be ignored.

Further, with regard to experimentation. Mr. Kenworthy, I think, said that every part should be fully developed by experimentation before being put into the production shops. This might be all right where huge quantities and big shops are concerned, but I think that it is not always possible in small works where quantities are relatively small. Tremendous amounts of money cannot be spent in small works on experimentation and therefore a lot of snags have to be faced actually in production.

Again, the question of jigging was mentioned, and the statement was made that the amount of jigging was dependent on the quantities to be produced. This is not altogether correct; jigging is very much

influenced by the demands of interchangeability, and if it is necessary to manufacture and supply spares which have to be fitted together in outlandish places where facilities are nil then interchangeability becomes a very important factor and one must be prepared to spend a large amount of jigging independent of the quantities produced.

With regard to the question of whether the Production Engineer should control the buying of raw material, I think this is a debateable one. The Production Engineer has his programme before him and knows what material is required for current production, but the General Management have broader views, have before them the potential requirements for spares, not only for immediate production but also for future demands spread over the estimated useful life of the machine.

One other important item was omitted and that is the question of dealing with corrections. Corrections are the bugbear of the Production Engineer and I should think that all of us who are engaged on actual production would welcome some fundamentals or some technique in the method of handling corrections.

Then again the greatest factor of all—the human one—was not mentioned at all. We are faced at the moment with a lack of skilled and trained labour. How can this be overcome? The Production Engineer is faced with the problem of producing accurate parts at low cost and he requires a supply of trained labour to enable him to do this. How can the difficulty be met? If the labour is not available in its trained form then it is necessary to draft raw labour into the works, and to train it to the degree of proficiency required. We must therefore provide facilities for such training. Intensive modern conditions demand that with his introduction into an incentive system, a boy must either make bonus, or get out. What system can we have which will allow him a training period? I think it is very necessary that some such scheme should be inaugurated. It can be done, but it wants attention and it wants sympathetic consideration for the lad entering industry, for whom it is essential that he should not become predisposed to consider his job as one of slavery.

MR. CLINTON: As a person who is not concerned much with the purely production side of engineering there is one point which was raised by Mr. Kenworthy which I think needs more attention in most works. That is the question of waste in transport. One finds that in many works the definition "The shortest distance between any two points is by a straight line" seems to be inapplicable, or generally ignored, and the waste of time and labour in the transport, not only of material, but of papers, and speech, is tremendous.

MR. COOPER: Most of the speaking to-night has been concerned with the engineering trade. It seems to me that in this trade, with such elaborate systems and such perfect methods of handling mater-

ials, etc., there is a great tendency to look at the system from a purely mechanical point of view, and consider even individuals as machines and part of the system, and it would appear very difficult to retain anything individual operating in these systems. It seems to me that any sense of craftsmanship must tend to get lost. I think it is a great loss to industry in general, not only engineering, that there should be any loss of craftsmanship, and that the individuals engaged should lose their individual touch with the finished product, and in fact any real interest, and I think a great attempt should be made and in many industries can be made to encourage the individuals engaged to take interest in the article on which they are employed.

This could possibly be done by means of lectures designed to stimulate the interest of individuals tied to one operation in the other operations necessary to produce the finished article, and also in the finished article itself. I, personally, am concerned with the printing industry, and it is rather easier in that trade to obtain interest in the finished article as it involves form, colour, and design, but I do not think it should be impossible in any industry. Undoubtedly, it seems to me one of the very important aspects of a production engineer's activities that he should endeavour by all the means in his power to encourage real interest in the finished article by all the people concerned in its manufacture. I think the question of money incentive, although important, is not the only way of dealing with this question of interest.

Another point which has been raised is the difficulty of instituting a satisfactory training scheme to enable the young trainee to obtain the necessary skill to earn full bonus. I think it is possible to devise a suitable scheme by working on a minimum wage until such time as the trainees are considered sufficiently skilled to be put on the bonus scheme. A scheme should be fairly easy to devise, particularly if, instead of wages being calculated on a piece work basis, they are based on the total number of minutes worked each day as is done in the Bedaux system. I know there has been some difficulty with this system, but it is very comprehensive, and I think there should be no difficulty in adapting it to a training system.

MR. WHITEHEAD: I was very interested in the last speaker's remarks. I think the present production engineer is the one person who is doing away with craftsmanship in production itself. If a production engineer is any good he should be able to produce an article with semi-skilled or unskilled labour. The old fashioned craftsmanship has been put into a different category—that of preparing for production. That type of man will be employed only in the manufacture of the equipment necessary for the production of the finished article. I think that to-day there is no room for the highly skilled craftsman in the ordinary engineering shop, only on

the toolroom side. Therefore, the craftsman, as such, has been removed from actual production.

MR. COOPER: When I say that in the engineering industry it is difficult to retain interest in the finished product, I do not necessarily mean craftsmanship as originally understood. There is no reason why a person engaged in production should not retain some small interest in the general excellence of the batch of work when finished. I certainly think that unless an individual takes an interest in his work the quality is apt to fall off, and that therefore the interest of the workman in the finished product must be encouraged if we wish to keep up the general good standard of British production.

MR. WHITEHEAD: I contend that the quality obtained a few years ago with very highly skilled craftsmen can now be obtained with unskilled or semi-skilled labour. I saw a machine yesterday producing a very accurate grinding job. When the operation cycle was finished and you examined the finished article you would think it was the work of a real craftsman, yet the machine was semi-automatic, and once it was set-up all that was necessary was to put the components into the hopper and the machine would do the rest. I think production to-day is boiling down to that, and I want to make it clear that I think the skill is going from the producer, and I don't think there is any incentive to make the man who loads the hopper take a pride in his work. He is merely a "robot" or should be, if the production engineer has done his job right.

MR. COOPER: In cases of an industry run on completely automatic lines it is no doubt extremely difficult to maintain any sort of real interest in the product, but I have not got in mind only the engineering industry. I have in mind the manufacture of other commodities, in which the engineering side is only a means to an end, such as printing, in which conditions are different. Elements of colour, design, and shape enter into the matter which tend to stimulate the worker's interest, although there is a tendency, even in printing, to work on mass production lines.

MR. JOHNSON: Speaking from the draughtsmen's point of view I think perhaps it is the draughtsman who takes a pride in the machine when he sees it finished. Certainly he is not a craftsman in the same sense as the workman, although he has got to do a lot of work on paper after a considerable amount of thought. Referring back to Production Management, no mention was made of the "Production Order," that is, the order for the machine, or machines, as the case may be. That order should be made out, perhaps 10 or 14 copies taken, according to the number of departments to which it is distributed, Design, Cost, Despatch, Production, Works Manager, Stores, etc., so that all are thoroughly conversant with the job being manufactured and know exactly what has to be made, date of test,

type and nature of same, date of despatch, and so on. I think it would relieve the work of the Production Manager if he had all these particulars. This also applies to other departments.

I believe Mr. Kenworthy said that material should be ordered to specification and that the specification should be decided with Design Department; also that raw material should be inspected, but there was another point which was not mentioned. It does happen occasionally that material is found to be short after the job is started through the shops. This is very unfortunate for the Production Department, and is usually an omission on the part of the Buying Department. The material has to be ordered, and I I think a list should be kept of the departments concerned so that the right people can be advised immediately the extra material comes in.

MR. ORGAN: I do not think that production engineers have given due consideration to the method of distribution of the overheads in their respective departments. As production methods improve and new expensive machines are introduced, the job eventually becomes more and more automatic, and semi-skilled and cheap class of labour is introduced. It is therefore obvious that the real earning capacity of any shop to-day should be based upon the machine and not on the operator. As we all know, there are machines employed to-day with varying purchasing cost, power used, and area occupied, and production managers are still content for the overheads to be distributed over their departments by an average general rate. I think a more accurate cost of production could be obtained by the application of a rate per hour on the machines, instead of the general average rate usually applied. Machines are to-day installed in shops at a very great outlay, which do the various operations very quickly as compared with older methods, and yet in many instances the same overheads are applied to these machines as were employed previously, and I think a true cost cannot be obtained under such conditions.

Another point is the differences in the rates of pay, and I fail to see that a machine operated by an operator earning say 6d. per hour, as compared with a machine operated by an operator earning 1s. 6d. per hour, the rate of recovery for the work coming off these machines should be three times as large in one instance as the other. I therefore feel convinced that a more scientific system for the distribution of overheads in factories where these conditions appertain is required.

MR. WILLIAMS: With regard to Mr. Organ's remarks in respect to the question of the grading of labour, I think the differences in the cost of labour make it imperative even under the existing system that the same grade of labour must always perform the same job. I have known cases when a shop has had to account for huge discrepancies in cost and it has been discovered that possibly the

job may have been done first by labour at 6d. and on subsequent occasions the same job may have been done by labour at 1s. 0d or 1s. 6d., and of course the discrepancy has been accentuated by the overheads placed on the job, but not only has there been a big difference in the cost of labour but in the shop charges as well. We should not base the shop charges on labour. The discrepancies in cost are so great, I think they should be based on the machine rate.

MR. CUBITT: I should like to make one more reference to the human interest element. Is it not true that although due to the change in the system of production the old idea of a craftsman taking pride in his work is changing, this is changing to the team spirit in which in a satisfactory factory the operator takes pride in belonging to the organisation. In regard to motor car manufacture, say, he points with pride to the numbers of cars which are on the roads of his firm's make and talks of their marvellous performances, and even tells his friends how his machine does work which adds to their safety or comfort. With regard to experimentation during production, my experience is that with quickly changing markets it is impossible to carry out all your experiments before it it necessary to go into production, and you do not really meet all your problems until you are in production.

MR. BRYANT: I am very much interested in the question of overhead charges, and am rather surprised to hear the system of application in such a highly organised business as engineering. My experience is that overhead charges should be allocated in accordance with the average wage rates in each particular shop.

MR. WILLIAMS: I do not think that would apply very well, because as Mr. Organ pointed out you may have a machine which cost £3,000 occupying 100 square feet and worked by a 10 h.p. motor, with the establishment charges based on the flat rate in the shop of say 8d., and alternatively you may have a machine costing about £25, not occupying anything like the space or taking anything like the same power, and carrying the same amount of overhead charges as the first machine.

MR. BRYANT: I am not suggesting that this is the best solution of the trouble, I am only suggesting it might be an improvement on the system at present in use.

MR. ORGAN: An example of the variation of the possible rates of machines in factories is instanced by an investigation into this matter which I undertook. After taking all the various items of expense which could be equitably charged to the machine, the variation in rate per machine ranged from as low as 3d. per hour to 15s. 6d. per hour, and where such conditions exist it is evident that a general average rate is not considered the best method of overhead distribution.

MR. WHITEHEAD: Don't you think the various arguments largely support my contention that every factory is different, and each has to be considered on its own? I do not think any hard and fast rules can be applied. There must be experience applicable to your own particular production.

MR. BRYANT: With regard to Mr. Whitehead's remarks concerning the human element, I am wondering what his particular trade in engineering is going to be like in the next generation, and where they are going to find the men who are to be the future Mr. Whiteheads. In some trades I understand the apprenticeship system has been dropped. Personally I do not think it should be altogether dropped, and some provision should be made to ensure that, in the future, industry will not suffer from the lack of highly skilled practical men.

MR. WHITEHEAD: I think the drop in the number of the apprentices to-day will be automatically balanced by the semi-automatic machines, and the few apprentices we do get will be ample for the few skilled jobs which will be left in the future, such as tool-making and setting. In the good old craftsman days the majority of the trained apprentices, when out of their time, became the skilled operators. To-day, these are replaced by the semi-skilled unapprenticed operators who turn out better work at a reduced cost.

MR. WILLIAMS: With regard to the future supply of skilled labour I think the occasion will produce the men. The present educational system gives most lads a secondary education and possibly a technical education, and I think it will be found that where a job is good, with prospects of advancement, there will be plenty of good, well educated lads to fill it.

MR. ATTWOOD: I think it is obvious that the future supply of skilled labour must come from the equipment side. These will come from the tool room, or the jig office respectively, the members of these departments after years of experience have the necessary qualifications, and they will be the source of supply of this labour in the future. With regard to the point Mr. Kenworthy raised about experimentation, he referred to experimentation on the finished article, but he did not refer to any experimentation for jig designing, and that would be well worth considering. The advice of the jig designer could be brought to bear to cope with any production high spots or anticipated troubles in the experimental stage before the issue of production batches, and I think it would be much better if this experience was behind the jigs.

MR. ORGAN: There was a point in Mr. Kenworthy's paper where he referred to experimental jobs in small quantities being done in production shops. In investigating these small quantity jobs one often finds that they have been put through on a day work basis, and times have not been fixed for them. In my opinion this is not

the best way to handle jobs of this kind, and I think that although it may mean extra trouble for the ratefixing staff these jobs should be done on a time basis. In instances where small jobs are done on day work, they often have abnormal times taken over them, because there is no actual incentive over the job, and I think no job should be done in manufacturers' shops without some time being fixed. In fixing a time for this class of job, I do not mean to convey it should be a keen time, but some time should be fixed in order to make it an incentive for a man employed on this class of work. I think this scheme should be extended further to incorporate all jobs done in factories, even in cases of maintenance and repair work. Each job where possible should have some time allowance on it, no matter how small it is. I do not think if there is adequate supervision that the quality of work produced under these conditions will drop. If your men are working for incentive you will get quality work with proper supervision.

MR. A. CAMPBELL-SMITH: The only thing which occured to me in regard to Mr. Organ's remarks is did he get the same quality of job when it was put on a time basis? I have no doubt that on daywork the quality was probably not as good as the price indicated, but I do think it probable when the job was put on a time basis that the quality dropped in sympathy.

MR. ATTWOOD: May it not have been a question of the booking being at fault that accounted for the big differences mentioned by Mr. Organ?

MR. ORGAN: I must confess that the time booking in most factories is the foundation on which the costs are completed, and from some costs I have seen I do not give much for the time booking, but I think again this is a question of supervision. It is up to the person in charge to see that the men book on the right job.

MR. WILLIAMS: I rather think this touches on one of the fundamentals. That is where you instal a system of timing these jobs, it is necessary also to institute some inspection or to increase supervision, and the cost of this must come out of the saving effected. I think this is one of the fundamentals of any incentive system.

MR. ROWBOTHAM then read a letter from Mr. N. Lansdell, A.I.P.E., engaged in the manufacture of fishing nets at Bridport, Dorset, which contained the following points: "I wonder whether any of the following random points may be of interest as indicating some of the special difficulties in textile work, and particularly ours. (1) The raw material, by its very nature, and also due to weather conditions is variable to an incalculable degree. (2) Recent years have seen a change in our trade, in that while formerly a machine once set might run for weeks and months, to-day we have to accept orders that involve runs of two to five hours (or even less), although it may take six to fourteen hours to reclothe and reset

the machine. (3) While all the work is of a similar nature, there is an immense range of different specifications. I have some 7,500 standards, but the average job has yet to be interpolated by calculation. (For this a formula has been devised, complicated to get, but easily used when once it has been worked out). (4) An important factor is the recognition of what is the proportion of output due to the worker, and what due to machine conditions and speed; with us an increase in workers' efficiency of 20 per cent. may mean only five to 10 per cent. increase in output. Increase in machine speed means a not-easily-determined increase in "mending" cost. (5) As regards fundamentals of management—I believe there is probably only one—justice (in the widest sense); the easiest way in a doubtful case is to put oneself in the other man's place, as it were, and then act accordingly. (6) By way of secondary factor there is the necessity of seeing that the conditions both of work and of the machines are right. (7) I would add—the least amount of rules and regulations consistent with getting the job done. (8) And also the highest wages the job will stand. (This last is necessary for other than "internal" reasons, in that our trouble to-day is shortage of consumers—and the more the wages, the more goods are bought.")

MR. ROWBOTHAM: I think the discussion to-night has been very varied. When we started I did not realise that there would be so much "cross talk" but the subject is a fundamental one and bound to cause some discussion and argument. Mr. Kenworthy will probably reply to some of the speakers, but it seems to me that out of the discussion two things have come. One is "craftmanship" and the other "costs." Well, I think that wherever this discussion had taken place, the result would have been much the same. It seems to me that production technique is bound to be tied up with these two things—craftmanship or quality—either quality from the craftsman or from the tool or machine that the craftsman or worker is operating, and also the cost of the job when it is put into the salesman's hands for being distributed to the consumer.

Several points were brought out on craftsmanship, and I think it was Mr. Cooper who pointed out that in his particular industry, the operator or the craftsman had really some goal at which to aim and something by which to appreciate his work in the final result. (I believe the industry referred to is colour printing). I agree with that, although another speaker pointed out, and quite rightly, that in most factories which were efficiently run, each unit, whether the production manager, jig and tool designer, part designer, or the engineering side looking after upkeep and maintenance of the plant, was infected with the team spirit and took an interest and pride in the organisation to which he belonged. I think this is generally true, and it is very good that it should be so, that each individual not only takes a pride in his own individual side of the

job but takes a pride and interest in the product that his firm are putting on the market. I think probably this feature is stronger in this country than in perhaps most others, and I believe that it is because of this characteristic that this country will keep its head well in front of many competing nations. I have had an opportunity of visiting and working in some other countries, and I am quite sure that one of the fundamental reasons why British industry will keep well in the forefront is that pride which the individual in each factory takes in his firm's product. That is the basis of its success and I believe that it will continue.

The Council in issuing their invitation to promote this discussion in the various districts has set out one or two points. I don't know whether you have all read the pamphlet but paragraph six is one which has been quoted by some speakers, Mr. Whitehead particularly: "Whether as an institution we can institute a set of fundamentals or principles which will govern this subject of production management technique." If we had made this meeting a debate, that is the question we might have put, and we might have taken a vote at the end of the meeting as to whether those present think that the Institution can or cannot formulate these fundamentals. If I were asked to judge the opinion of this meeting, I should say from the discussion we have heard that this meeting is of the opinion that the Institution cannot formulate a set of fundamentals or principles which will form production management technique. I will now ask Mr. Kenworthy to reply briefly to the points raised.

MR. KENWORTHY: I am going to reply to the discussion in a general sense, as I do not pose as an authority on our subject, but simply offered to open the discussion, in order that we may attempt to establish some fundamental points.

As Mr. Rowbotham pointed out, two principal points arose during the discussion, the human element in production, and the allocation of overheads. I did refer in one or two instances to the human factor, for instance, to giving a square deal to the operator, and also pointed out the fallacy that existed at one time that immediately a man was earning a little more than the recognised wage, an attempt was made to cut the price. That fallacy is dead, and I think it is now realised that by a man earning more the cost of production is actually reduced.

The question of training recruits for industry has been referred to at great length. I do not propose to say anything further about that now, because it is the subject of one of our lectures this session, "Recruitment and training for engineering craftsmanship." That is a subject that the Council have asked us to put on the agenda because they have already realised its importance in relation to the engineering industry. We shall all have an opportunity of going more fully into that question.

The allocation of overheads has been a very debatable point for a number of years, and I think it is a very essential one which must be considered in regard to the conditions existing in each particular works. In many cases there are large machines which cost a tremendous amount of money, but the cost of the labour employed is very low, and if a percentage on labour factor is utilised for applying overhead costs, the actual cost is shown to be very low. If the shop is working on a general contract, the total cost may level itself over the whole of the works and the result will probably be very similar to what it would be if each machine was separately rated for overheads, but when it comes to the point which Mr. Williams raised and individual times and individual costs are necessary, then it becomes a different matter and more accurate costs are essential for each operation performed. That is another subject for discussion on our agenda this session.

Mr. Whitehead said at the beginning of the discussion that it was impossible to lay down any set of fundamentals which could be applied to all conditions. I join issue with him. I consider that a set of fundamentals does exist and can be laid down, but the method of application will differ. It will differ to such an extent owing to the varying conditions of production that the fundamentals will only be recognised after an analysis of the system in operation.

With regard to the question of experimentation before production, that of course can only be applied in large shops. Where large quantities are being made the experimenting on or trying out of jigs, as mentioned by Mr. Attwood, is very desirable, the biggest difficulty there being that you cannot try out a jig until you get the material, and by the time you have got your material you should be in production, otherwise you have your material lying about in the works and this will often cause the lock up of a large amount of capital. The actual try-out of jigs often has to proceed during the early production period. The question of jigging being not only a question of quantities but also of interchangeability. There is one firm in Bristol who are called upon to make a commodity from time to time in single units, and they may be called upon ten years hence to provide a replica of it, so they must keep masters. This means that the cost will be increased, and I had this in mind when I said that cost was one of the controlling factors with regard to jigging.

The question of whether the purchasing of raw material should come under the production manager has been mentioned. In my opinion this is a very essential point. I think that although the purchasing of any commodity in the factory should be under the control of the management or the accountancy side of the organisation, the purchase of material is a very essential consideration in

the cost of production, and a great deal can be done in getting the right kind of material. The production manager is responsible for the ultimate cost of the product so he should be responsible for the ordering of raw material which is an essential part of the manufacturing cost.

Mr. Williams raised the point of dealing with corrections. I say "cut them out." I know this is a very simple sort of solution, which is very desirable. It all depends on the skill, shall we say, of the operator on the particular operation and the quality of the tools and equipment issued, and probably comes back to the type of labour and the human element. We know corrections are a nuisance, but I do not think we ought to cater for them, but rather try and organise efficiently and get rid of the necessity for them. When they exist to any great extent, they are a reflection on the management.

Mr. Clinton mentioned transport, and he mentioned the transport of papers. I think one of the difficulties in this connection arises from the fact that most firms start in a small way and get built up piecemeal and add offices when they have to, where they can find room for them, and eventually have offices here, there, and everywhere.

Finally, I would again refer to the title of our discussion—"Production Management Technique." I don't think that we, as a section can definitely say that we can establish a set of fundamentals. I would suggest for the consideration of our Council that they, as a Council, are the only people who are probably in a position to establish a set of fundamentals, and I would suggest that the way they can do this would be to establish a small sub-committee to investigate the conditions existing in successful organisations in various parts of the country. They should take organisations using line production, organisations doing one off jobs, and a series of grades existing between these two extremes and analyse the conditions. This should be done with successful shops only, and from this they should be able to establish a set of fundamentals which can be considered to be the basis of this technique. I think this is the only solution.

PRODUCTION MANAGEMENT TECHNIQUE.

Paper presented to the Institution, Birmingham, London, and Luton Sections, by George Still, M.I.P.E., A.M.I. Mech.E., A.M.I.A.E.

THE title of the paper to which you are asked to give your attention to-night can be interpreted in a variety of different ways. You will doubtless realise that in giving a paper of this character, it is extremely difficult to do so without being unduly influenced by one's own personal experiences, and yet the relating of those experiences and the attendant amplification of what steps were taken to deal with the situations to which they relate, is only of superficial value, as it does not attempt to get down to the broad fundamentals or guiding principles upon which production work in industry should be built up.

The task of constructing a paper suitable for presentation to the Institution is rendered even more difficult because of the varying lines of action which would need to be taken in such widely diversified trades as, say, a large automobile works, producing 1 to 500 complete cars per day, employing thousands of people, and the smaller good class general engineering shop employing, say, three to four hundred hands. It does not need a great imagination to realise that there are few principles which could be successfully advocated or applied to both classes of factory with anything approaching equal success.

We shall, perhaps, better appreciate how extremely difficult it is to find any common ground of agreement in regard to systems or line of actions indicated if we first of all refresh our memories in regard to the distribution of factories in our land. These I have extracted from the annual report of the Chief Inspector of Factories and Workshops for the year 1932. This report was issued in July, 1933, and at the time this paper was prepared the 1934 issue was not published. The figures, therefore, will have varied slightly but not to any appreciable degree. They are as follows:

Birmingham, September 19th; London, October 5th, 1934; Luton, April 10th, 1935.

Size group	*Number of factories*	*Percentage of total*
1- 25	103,730	7 .4
26- 50	11,571	8.6
51- 100	8,113	6.1
101- 250	6,830	5.1
251- 500	2,421	1.8
501-1000	949	0.7
1001 and upwards	421	0.3
	134,035	

You will see, therefore, that of 134,035 registered factories, only 3,791 employ more than 250 people, whilst only 949 employ more than 500, and the number employing more than 1,000 is but 421 or 0.3 per cent. of the grand total. Shall we, therefore, talk of production management technique with these large factories in mind, remembering that there are under three per cent. employing more than 250 people. If we do so, the many members of our own and other institutions employed in the smaller factories will say: "Of what use is all this to me?" On the other hand, if we talk of production management technique in an attempt to cater or solve the problems confronting officials employed in the factories employing under 250 people (and remember these constitute 97 per cent. of the grand total) then all of us who happen to be employed in the larger works will say: "We left all that behind years ago." In fact, we may not express ourselves so politely as that.

I think, therefore, that during the short time at our disposal, we shall do better to generalise on production work, rather than attempt to talk on either the very large factory, with its repetitive methods, or the very small factory where production organisation would be rarely called for. I think, perhaps also, that we shall the better understand our object if we attempt very briefly to trace the reasons which have caused the need for any variation in production organisation from that which prevailed until a few years ago. I will, therefore, claim your indulgence while I briefly refer to the influence that engineering has had on the advance of production during the last century, and I think that in doing so we shall find the explanation of the evolution of production organisation and its present day function.

For this evolution, I want to use the description given by Mr. Groocock when addressing you on a former occasion, because the stages are so beautifully yet simply explained that I do not think it possible to improve upon them.

When we look back to the time of Watt, Bolton, and Stevenson, and realise that during the time that has since passed, the standard

of comfort of our people has been advanced probably more than it had in the previous thousand years, we have food for thought, particularly when we find that this rapid advance has been due largely to the influence of the engineer. These men then built the foundations for the huge edifice we now call engineering, and the more we examine the work they did, the more amazed we are at the soundness of the foundation they prepared for us. We have been told that "Mankind would make very little progress in science or art, if they made no use of the experience of their predecessors." Those early engineers soon realised this truth, and formed among themselves associations which should act in the way of bringing them together, thus forming a clearing house for their ideas.

Retrospection shows us that the rapid increase in the standard of comfort we are enjoying to-day, is largely the result of the work of these pioneers. By the introduction of machinery, they not only replaced the drudgery of manual labour by mechanical devices, but these machines did more than reduce drudgery. They increased production enormously. Transport too, kept pace, and evolved the steam locomotive, internal combustion engine, and ocean-going liner, and this assisted in the distribution of the commodities thus made.

During the nineteenth century, not only did the work done by the engineer grow very rapidly, but it became extremely complicated, with the result that some measure of specialisation was forced on the engineering industry. It soon became apparent, for instance, that the only way to make articles in quantity, and cheaply enough to extend our markets, was to make them accurately within certain defined limits, and this was the birth of interchangeability. This change in the basis of manufacture eventually made a wonderful difference, both in quantity, quality, and price. Incidentally, too, it was the real beginning of the production engineer, although it was many years later before the name came into current use.

Interchangeability is impossible without standardised tools and gauges, and this development brought along eventually the tool room. At this stage, the tool designer materialised, first as a junior who could put on paper the ideas of the tool room foreman and others, later as a specialist with his own ideas. Now, no one can design efficient jigs, tools, or gauges without a full knowledge of the operations and processes involved, and the necessity for having the operations in a logical sequence is recognised as one of the first considerations for successful manufacture. Here, then, was the beginning of the planning department.

The next step was to have someone to see that the work, instead of stopping on the floor after the first or subsequent operation, was carried forward and progressed at the desired rate from one operation to the next, until completion. This brought along the progress

man, and at this stage, in order to ensure correct interchangeability, inspection was found to be necessary.

A proper co-relation between the manufacture was found to be essential if we were to get work through in the desired time, and this led by uneasy stages to the production department. Here experience soon demonstrated that to be successful, the man in charge of production, must not only control the manufacturing processes from the very beginning, but must also control the supply of raw material, and all this brought forth the need for the man—the production manager.

Those who spend your business lives in other spheres than an engineering factory may ask "What is a production engineer?" "What is his work?" "What *are* his problems?" An old chief of mine, some years ago, upon being asked these questions by a colleague, regarding his own production engineer, replied: "He is the axis upon which the factory revolves." Modesty on my part would prompt me to use a somewhat less ambitious description.

Doubtless, some of you, especially if there are any amongst you who have been away for some years from manufacturing plants, will exclaim: "Well, what is the responsibility of the works manager?" This thought is a natural one, because until a few years ago, one man was in complete charge of a factory. He was usually known as the works manager, and was quite able to take care of the whole of the activities of a manufacturing concern, but with the increasing importance and complexity of production problems, the production manager has largely replaced the previous works manager, the latter confining his activities completely to "managing the works" without undertaking the responsibility of the actual factory output.

There can be little question that the term "production management" has assumed a significance almost unrecognisable with that for which it stood a few years ago. The two main reasons which have brought this into being are: (1) Rapid development of mass production units, and (2) the sub-division of responsibility. Both these factors are necessarily intertwined and call for a very highly developed management technique.

The camera obscura of production management is no longer that of personal contact and visual inspection. It has been almost entirely supplanted by statistical control, and the leadership which is necessary for successful production management must be based upon carefully devised methods which set standards of performance and continuously evaluate the efforts of each individual against such standards. Upon the accuracy of this continuous statistical analysis depends not only the material success of the organisation, but also the preservation and development of the human contacts throughout the organisation.

The moment any individual or group of individuals realise that their work and their efforts are being properly *understood and recognised as well as being evaluated and rewarded*, confidence in management is established and confidence is the first essential to success in any form of management.

One of the main planks of production management is unquestionably the development of ability to analyse, in just the same way as any scientific problem is attacked. This analysis can be subdivided into two main groups: (1) The evaluation of the organisation of personnel; (2) the organisation of systems.

With regard to the organisation of personnel, it cannot be gainsaid that the evaluation of the capacity of each individual in the production management personnel, and the grouping of these individuals in accordance with that analysis is the fundamental of successful management. In other words, whatever scheme of organisation is decided upon, success depends upon the men chosen for the task, and therefore provision has to be made for the organisation to be built round the individuals in some instances, and not the individuals accommodated to a set scheme of production organisation. If this statement can be accepted as being one of fact, then it is not difficult to appreciate that no two organisations, although producing similar products are, or can be, successfully organised on lines which are even approximately similar.

Upon the organisation of systems, and by that is meant the clerical control systems, much of the effectiveness of management depends. These systems, involving as they do many and varied forms of paper work, can be regarded as works currency, and perform a function very similar to that of national currency. Just as national currency expresses quantity, quality, and value, so works currency expresses these qualities, and in addition, compiles the past and current history of the manufactured products.

There is a further similarity between works currency and national currency, namely, in the rapidity of circulation. Usually, the greater the speed of circulation of currency, the greater the prosperity it expresses, and the prime essential of any clerical system must be the speed with which the information it collects flows back to the central point, at which point all data is collated and summarised into the various forms required by production management for its guidance on policy and control.

It is, therefore, not very difficult to understand that, apart from the qualities of leadership and human understanding, inseparable from any scheme of management, the technical and financial make up of production management is very closely intertwined, and in any scheme which pretends to prepare individuals for future management responsibility, the principles of accountancy, works costing, and the rapid translation of all technical effort into money value,

is so important that no emphasis on this aspect of management can be too great.

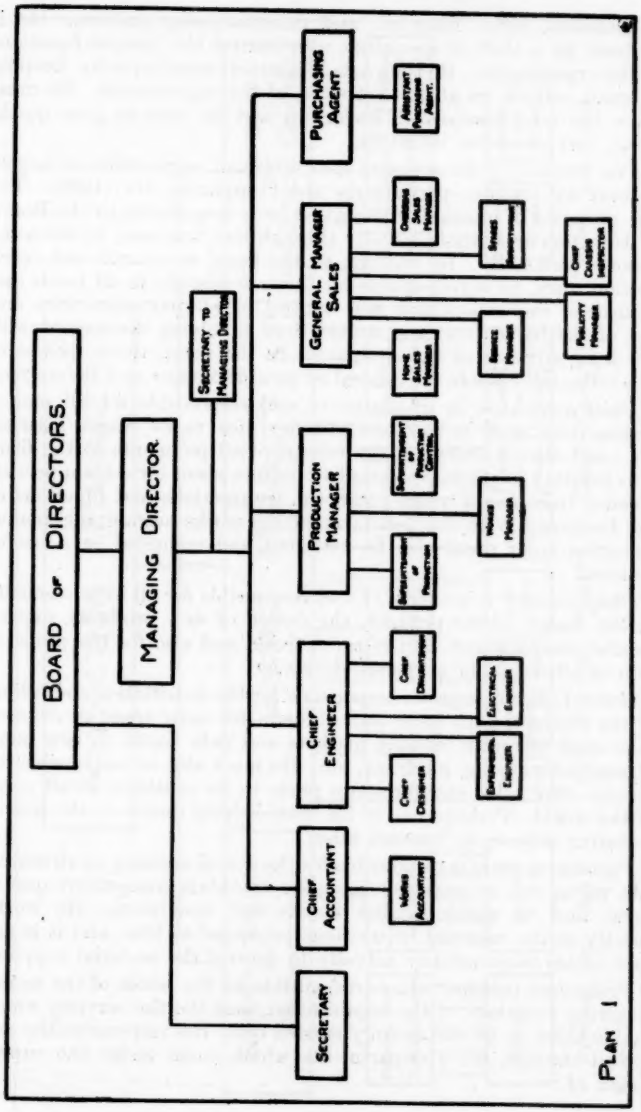
National currency has been evolved to simplify the daily life and operations of the individual and communities, and is a vehicle used as a means of expressing the movements and habits of individuals, as well as the movement and value of goods in reasonably precise terms, and it is, therefore, a logical step to expect that factory management should use the same language to express the detailed and collective results or forecasts of manufacture, and should use this language in all its direction of effort of works personnel. Coupled with this ability to express technical effort in common currencies, is the ability to forecast results in any given combination of circumstances, and this particular technique of management can only be developed to a high degree of exactitude if the past and present data which the works currency expresses is used as a continuous analysis. It will often be found that by expressing one component of cost as a fraction of the whole, or as a percentage of some other component of the total cost, new light is brought to bear upon either purchasing methods, operation methods, or production management methods.

There have been many excellent books published by different people, setting out the ideal works organisation. Certain chapters in these books appeal to those of us who are actively engaged in factory management as having been written by people who were filled more with hope than confidence, and certainly some of the statements made and advice given, if taken seriously by the student towards whose education they are intended to contribute, will be the cause of a tremendous shock to the reader upon entering the average fairly well organised factory, because he will find in actual fact that few of the theories which are enlarged upon in text books will actually be in practice in the factory organisation. It should not be thought that this statement is intended to deprecate the information contained in such text books, as some of their authors are men with experience and knowledge of the actual management of factories.

In order to explain how responsibilities can be divided without any clash of interests, I should like to show you two plans of an ideal works organisation, the first embodying all its principal officers, showing the place in management of the production side, and the second amplifying the duties of the various officials controlled by the production manager.

Referring to Plan I, a very casual survey of the duties which officers other than the production manager cover is called for. It may, perhaps, be wise briefly to refer to these.

Managing director is responsible to the directors for the whole of the business functions. His position demands a keen knowledge


BOARD OF DIRECTORS.
MANAGING DIRECTOR
SECRETARY TO MANAGING DIRECTOR
SECRETARY
CHIEF ACCOUNTANT
CHIEF ENGINEER
PRODUCTION MANAGER
GENERAL MANAGER SALES
PURCHASING AGENT
PLAN I

of business, legal, financial, and manufacturing matters. He is assisted by a staff of specialists who control the various functions of the organisation. He then acts in a supervisory capacity, keeping a broad outlook on all the activities of the organisation. He must have the qualifications of leadership and be able to give quick, clear, and complete decisions.

The Secretary of the company has duties and responsibilities largely defined by statute, particularly the Companies Act (1929). For the purposes of internal organisation he is responsible to the Board of Directors as a whole, usually through its Chairman, to whom he reports personally. In addition to the usual secretarial and registration work, he is responsible for the safe custody of all funds and securities, the supervision and control of all payments into and out of the banks, and any negotiations involving discussions with the legal advisers of the company. In the main, the activities of this office fall outside the general scope of the paper now before you.

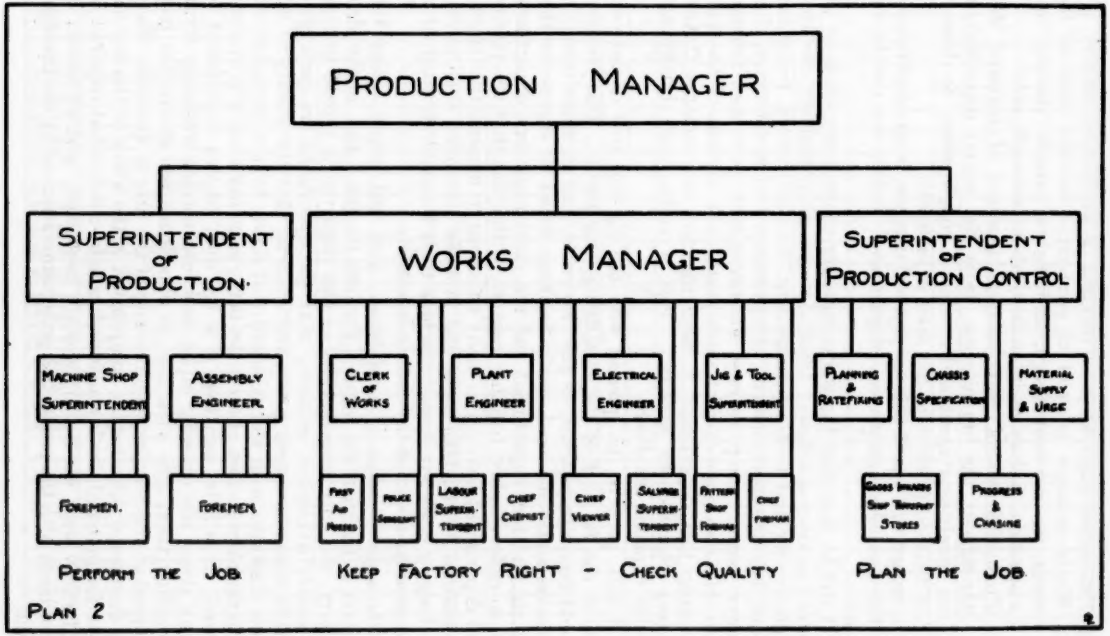
Chief accountant is in charge of and responsible for all money transactions, such as payment of bills, rates, taxes, wages, salaries, etc., and also in charge of the receipt of all payments to the firm. It is his duty to prepare a complete balance sheet for certain periods given a true money value to all the transactions and functions of the business. With the assistance of the works accountant, manufacturing costs must also be collected and compiled in a useful manner.

Chief engineer is in charge of and responsible for all improvements in the design of the product, the design of new products, experimental, development, and research work, and also for the preparation of all complete workshop drawings.

General sales manager is responsible for the distribution and selling of the product, both home and abroad. He must train an efficient sales staff to retain existing markets and gain access to new ones, arrange advertising, publicity, etc. He must also be responsible for service after sales and for spare parts to be available in all parts of the world. Perhaps one of his most helpful duties to the manufacturing side, is to forecast sales.

Purchasing agent is responsible for the actual ordering of all materials, parts, etc., to interview salesmen, to obtain competitive quotations, and to watch market trends and conditions. He works strictly to the material requisitions presented to him, and it is not part of his responsibility actually to control the material supplies.

Production manager who is responsible for the whole of the manufacturing functions of the organisation, and the the services which enable them to be successfully carried out. His responsibilities are spread through three departments which come under the supervision of :


PRODUCTION MANAGER
SUPERINTENDENT OF PRODUCTION
WORKS MANAGER
SUPERINTENDENT OF PRODUCTION CONTROL
MACHINE SHOP SUPERINTENDENT
ASSEMBLY ENGINEER
CLERK OF WORKS
PLANT ENGINEER
ELECTRICAL ENGINEER
JIG & TOOL SUPERINTENDENT
PLANNING & RATEFIXING
CHASSIS SPECIFICATION
MATERIAL SUPPLY & URGE
FOREMEN.
FOREMEN
FIRST AID POSTS
POLICE SERGEANT
LABOUR SUPERINTENDENT
CHIEF CHEMIST
CHIEF VIEWER
SALVAGE SUPERINTENDENT
FITTERS SHOP FOREMAN
CHIEF FOREMAN
GOODS INWARD SHOP TRANSPORT STORES
PROGRESS & CHASING
PERFORM THE JOB
KEEP FACTORY RIGHT - CHECK QUALITY
PLAN THE JOB
PLAN 2

(1) *Production superintendent* (control of productive labour).
(2) *Works manager* (control of productive services such as tool room, jig and tool design, millwrights, process viewing and inspection, factory maintenance, labour strength, etc.
(3) *Production control superintendent* (control of material flow throughout the organisation, from the actual requisitioning on purchasing agent and receipt in rough stores, to delivery of finished product to the sales department.

In regard to Plan II this, as you will observe, is an amplification of the production managers' department, and is set out in full detail.

It will be seen that the works manager controls the whole of the factory services as follows : Clerk of works, plant engineer, electrical engineer, jig and tool superintendent, first-aid nurses, police sergeant, labour superintendent, chief chemist and metallurgist, chief viewer, pattern shop, salvage superintendent, and chief fireman. You will also observe that underneath that portion of the plan covering this department I have inserted the remarks " Keep factory right—check quality." This, I think, very briefly and neatly explains his duties.

It will, perhaps, be queried why the jig and tool department should not be part of the rate-fixing department. This criticism would be quite justified, as the two could, and in many cases do, function under one head, but it has been found by experience that the jig and tool department and the plant engineer's department are so closely linked together because of the fact that the jig and tool department have on so many occasions to manufacture special accessories for machine tools, and in a few instances, even having to design completely special machine tools throughout, adapted to the peculiar needs of the firm in question.

The superintendent of production. You will notice under this section of the plan the words " Perform the job " and, in the ideal factory, the only responsibility of this department should be that of general discipline, ensuring that the operations are performed within time allowances given, and ensuring that the quality of the work conforms with the standard laid down by the management.

In the third section of the chart is the *superintendent of production control.* It will be seen that it is the duty of this department to break down the drawing office lists into correct workshop form, compiling them into such lists as experience has shown are best adapted to the peculiar requirements of the firm in question. They are then responsible for the compilation of the whole of the requisitions for material, both rough and bought-out-finished required in conformity with the lists previously mentioned, and of course, in accordance with the production programme required by the management.

P.C.D MACHINE COMMITMENTS

A163. 4 CYL PETROL ENGINE. NON FERROUS METAL SHOP. SHEET 1.

PART No	DESCRIPTION	OFF	CTA	CTC	CCL	ELB	GC	PDP	PDB	RDP	RDB	MGB	MMB	MTC	CMB	BC	DG	DG	
			TURNERS							DRILLS			MILLS			MISC			
A13811	Main Bearing Cap Fr.	1							4.5				1	3					
A14424	" " " C.	1							3				.75	3					
A14425	" " " Rr.	1							4.5				1	3					
A15414	Timing Wheel	1	10.5				4.5		9							2			GC GR.
A15621	HT Lead Brkt	2							2.5										
A16104	Camshaft Bearing Fr.	1			37.5		52.5	1.5	2.3						1.5	.75	1		
A16204	" " C	1	8				15.5		4						5.5		2		
A16205	" " Rr.	1							1.5						4				
A19203	Dipstick Knob	1			5														
A19715	Oil Filler	1	6						1.5								3		
A20904	" Pump Wheel	1			1.5		4	1								.75			GC.
A21204	Cover	1			13				14.5						6				
A21410	Fan	1		25								12.5							
A23817	Water Pump Body.	1	30						8						2.5				
A23819	" " Cover	1			8				4										
A24007	" " Vane	1			2.5														
A25221	Induction Pipe.	1									2.8	3.5	9.5	18.5					
	TOTAL (Mins)		54.5	25	58		305.5	5.5	57.8		2.8	6.75	13.75	27.5	19.5	3.5	3	3	
TOTAL	TIME 100 OFF (Hours)		91	41.6	56.7		51.2	4.2	98.8		46.8	7.9	20.4	45.9	32.5	5.8	5	5	
Mcs	REQUIRED 100 PER WK - 47 HR WK		1.93	.88	1.21		1.09	.09	2.1		.99	.17	.43	.98	.69	.12	.11	.11	

SPECIMEN SHEET.

These requisitions are sufficient authority to the purchasing agent to buy the parts enumerated, and a copy of the actual order is ultimately sent to the P.C.D. who then become completely responsible for the commercial transactions with all the suppliers, to ensure that deliveries are effected in accordance with the trader's schedule, which is also compiled by the P.C.D.

Whilst this section of the work is being dealt with the planning and rate-fixing department, from a duplicate set of blue prints, are also preparing layouts showing the necessary operations, machines upon which these operations are to be performed, stating the necessary jigs or fixtures required for same, and setting time allowances necessary for the fabrication of the rough material, upon receipt, by a man of average ability. At the same time, this section also ascertain by analysing the machine load, whether sufficient machine hours are available on the various types of machine tools involved to permit of the manufacture of the parts within the period specified. If these hours are not available in an ordinary dayshift on the machines specified they have to arrange for either: (1) Overtime; (2) double or treble shift; (3) in isolated cases alternative methods of manufacture in the event of too heavy a load on the correct machine tool. This, of course, would be an alternative to purchasing additional machine tools of the correct type which might prove uneconomical. Concurrently with the foregoing, the progress department is preparing the necessary progress records for the use of foremen and shop chasers. These usually cover a period of eight to twelve weeks, varying slightly with the fluctuating demands on the factory.

Upon receipt of the rough material, the P.C.D. accept the full responsibility for the whole of the goods receiving section, and are also responsible for all the rough and finished stores throughout the factory, together with the whole of the shop transport, the latter working in conjunction with the section chasers, thus ensuring a material flow in conformity with progress sheets in the latter's possession. There are so many very excellent standard works covering the last mentioned group of duties that I do not propose to dwell on them at any length, and have only briefly referred to them in an attempt to discover what are some of the main features about production management, so that we might consider for a few moments to which aspects we might perhaps give attention.

There is a great temptation at this stage in the paper to enlarge upon one particular system or set of systems, being that obviously which has successfully solved one's own problems, but whilst it is apt to assume aspects of major importance in the eyes of those whom it has served, I do not think this would make any real contribution towards the explanation of the "Technique of Production Management."

There is always a great danger in attempting to solve another man's domestic difficulties, and although factories or groups of factories following similar trades, and maybe employing labour of similar grades and quantities, may seem alike, there will always remain problems of a psychological, geographical, or other character which are peculiar to one individual plant or group of plants. Any attempt, therefore, at a general solution of difficulties would be negatived.

I think, perhaps, a simple explanation will suffice. I live in a road in the suburbs of London where the houses are all of about an equal value. Most of their occupants are of a similar grade to myself, and I daresay the average for each house, including wives and children, might be four. There is, therefore, no reason why a system could not be evolved whereby each house could be run on exactly similar lines, but you can imagine the reception I should receive, if I went home and told my wife how excellently Mrs. Smith ran her home, and could she please adopt the same system. This, of course, would be nothing in comparison with the uproar which would ensue if my wife extolled the virtues of how Mr. Smith kept his garden and lawn and carried out other domestic obligations, and could I please follow the same system.

I propose, therefore, to call special attention to two points only of those mentioned.

Material control.—You will doubtless have noticed that in the scheme which has been outlined to you the control of material remains the sole responsibility of the production control department and not, as of old, that of the purchasing agent. This has been inserted very deliberately, and is advocated as a result of many years of experience in engineering factories.

It is a recognised fact that engineers are never without an excuse regarding their inability to deliver the goods, either: (1) Material was too hard; (2) the stampings were too proud; (3) they had not been sandblasted; (4) the jigs were not there; (5) if they were the locating points or some other feature were inaccurate; (6) a viewer could not be found; (7) the time allowance was inaccurate; (8) the heat treatment specified was incorrect; (9) the feed and speed specified were incorrect; (10) drawing was not available, and many others of a similar character. When one has been amongst these things for some little time, there are obvious answers to each of the points raised, but the people in the factory under the old system had one excuse which could never be overcome, i.e., "We are waiting for material."

As the responsibility for obtaining this material was usually that of the purchasing agent, everyone in the factory immediately became exonerated, especially if they had already sent a chit along to remind the purchasing agent that this would occur. Experience, then,

has shown that the obvious way to overcome this trouble is to allow the factory to progress the outside supplies of material for themselves in just the same manner as they also progress the work within their own building. After all, under the old scheme the factory had to supply the purchasing agent with all the necessary lists of requirements which he, in turn, had to duplicate to the suppliers. Upon receipt of information from the latter, the purchasing agent had again to transmit this information to the factory. Surely, therefore, on the grounds of economy and delay alone, it was a costly business for this duplication to occur at both ends. Also the factory know by experience exactly how long it takes to obtain each class of material, as for instance, annealed castings, and they also know the period it takes for various classes of work to pass through all the operations within their own shops. They know further for instance, that it is wise to take the first cut off cylinder blocks and leave same in the open for a period to relieve the strains and stresses, and allow maturity to occur, thus necessitating larger stocks of work in progress. Therefore, with all this information which they gather in the course of their everyday duties, they are best able to convert this into instructions to the suppliers which will ultimately help to prevent any hold-up in the rough material arriving, and at the same time will also ensure that the material does not arrive in excess of the actual requirements, so causing losses through heavy tie-up of capital, etc.

The controlling of the material supplies from outside by the people who actually requisition same on the purchasing agent, also eliminates the keeping of another complete set of card records within the purchasing agent's department, as the stores order card record upon which the details of the requisitioning are inserted, is also left with sufficient columns to insert the details of the actual order upon receipt of the duplicate copy from the purchasing agent's department. Further space is also provided to insert brief details of the " follow-up " such as telephoned, written, telegraphed, personal visit, dispatch promised, etc.

Incidentally, this card record of each individual part number is the only one throughout the factory, as it provides, in addition to the items just mentioned, for record of : (1) Rough stock available ; (2) stock W.I.P. ; (3) stock in finished stores ; (4) stock issued to assembly section ; (5) assembled components completed. Thus, when the position of any part such as, say, a crankshaft is required, the superintendent concerned has only to call for one card, and from this he can instantaneously gather the whole of his stock and commitment for the part in question, together with all the history of same.

This information is invaluable, as in the event of a hold-up occurring, the reason can be instantly traced, exposing whether it

was requisitioned too late, whether delay occurred in the sinking of the dies, whether delay occurred in the lining out and checking of the first sample stamping, and so forth, and the knowledge that all such information is in the hands of the one clerk involved, and that any error or omission can be tied down to one individual has a wonderfully stimulating effect upon the people concerned. This point alone could be dwelt on at much greater length, but I trust the brief explanation I have given will be sufficient to explain why this responsibility is placed direct on the factory, and we may, perhaps, find time at the end of the paper to answer any points of doubt which may arise in your minds.

The second point which I should like to emphasise is that of machine loading. This is definitely an issue which does not receive anything like sufficient attention in the average factory.

It cannot be emphasised too strongly during the training of the works student, or any of the staff concerned with production management, that the only time when machine tools are really revenue earning is when they are actually making chips, or otherwise removing surplus metal, and if any of you will take the trouble and care to stand for five minutes in the machine bay of the factory, of any kind, which you next enter, and count the machines within the range of your vision which are actually making chips, I will guarantee that you will have a big surprise. You will doubtless see an operator at each machine or group of machines, but a large proprotion of them will be lifting parts on to the machine, chucking same, releasing from chuck, gauging, examining blue print, etc., and while all these actions may be very necessary, you will usually find out that whilst they are being performed, the machine is not actually cutting or making chips. It is, therefore, very well worth while in every machine shop, no matter how small or large, to take every possible action to minimise these extraneous duties as far as possible.

I have studied this machine loading question very closely, and although sometimes when looking round at the result obtained I feel disappointed, I do realise that without the effort which has been put into this particular phase of our work, the results obtained would have been even less satisfactory. If, therefore, we can carry some of this interest and enthusiasm into our various factories, I at least shall feel that our time has not been altogether wasted.

In studying this question, we have to keep in mind that it is not many years ago that the production of a factory was almost entirely controlled by the issue of drawings from the drawing office. The order clerk or stores would order the raw material as they received the drawings, and the foreman would decide how and in what order the parts would be made, his decision being largely governed by the fact that to-morrow Joe, the driller, would want another

job, and the next day Bob and Harry, the turners, would be finished their jobs also. The works manager (if any) presided over the whole affair, and his experience and tact enabled him to make just the right guesses to enable the whole thing to work somehow.

As works grew, as competition became keener, and production requirements more intense, and while the proportionate amount of capital did not increase at the same rate, the realisation of the need for a scientific study and control of the factors affecting economical production became more important, so that now we have a separate department which specialises in these matters, and this has become a vital part in the organisation of any machine shop.

The machine loading of the machine shop is really the number of hours required by the machine or machines in question to produce parts in order to keep pace with the rate of assembly. Sometimes this load necessitates working short time on some machines, whilst at other times it necessitates overtime or double shifting. It is usually expressed as a comparison with the standard working week of forty-seven hours. If the load per week is forty-seven hours, this is called 100 per cent. load.

The finished layout for the fabrication of the part forms the foundation on which the machine load with its various uses, is built. On it is information regarding the sequence of operations for use in a progressive machine line specialising in one component, such as say, valves or brake shoes, On it also, are the machine symbols showing the type of machine, if it is one of a common class, or a more minute description if the work can only be carried out on a certain machine. This machine bay or section is indicated, and of course, not least in importance, the time allowance is given on a floor to floor basis for the performance of the operation.

The machine load or commitment sheets are made out for each bay or section, and along the top of the sheets are the machine symbols belonging to that bay or section. Down the left-hand edge the part numbers are entered, and extended along under the machine symbols are time allowances for the quantity of each part number required per chassis.

The information regarding part number and quantities per chassis is obtained from the schedule compiled in the specification section, which is also used for ordering purposes by the stores order section. This again is an instance of how one document can be utilised for two distinct purposes, and from it, the third document can also be constructed. This document has been described as "the finger on the pulse of the works." I think the foregoing simple explanation will enable you to understand how the total time required per chassis for each type of machine on each bay or section can be quickly ascertained.

A point of interest is that at the moment, these sheets are being

used in one works in the manufacture of about 34 types of chassis. Naturally, we do not make up the 34 different sets of machine loads, i.e. one for each chassis, or we should be repeating identical sheets many times where the parts are common. Actually, the system allows of condensing the common parts so as to reduce the number of these, but even so, the amount of study is rather great, as one of these machine loading books has reached 250 sheets, each containing an average of 15 part numbers, and each part number having an average of four-time entries. There are thus 15,000 time entries in this folder which have had to be examined and entered, in order to make up the grand total of machine hours required. I will not weary you with further details of how the information is arrived at, but would ask your indulgence while I explain briefly how the information is used, as like all statistics, it would be so much waste paper unless it could be used for some valuable purpose.

Obviously, its principal use is to show which are the most heavily loaded machines that are likely to impede production. On normal production a machine load is made up by taking each chassis in terms of time and multiplying the machine totals of each section by the required weekly chassis output. In this way the machine total on each section is increased from one chassis' worth to one week's chassis worth, and totalled to represent the load in hours to machine a week's work. Then we have something useful. Suppose we have three No. 10 Ward lathes in a bay, and the load is ninety-four hours, then two will work full time and the other will be idle unless some other work is found for it, or alternatively, all three work and run themselves out of jobs in the near future. Suppose, on the other hand, the load is 235 hours, then two machines must be double shifted and one work single shift. Unless this is known in time the work will get behind, and if the machines are working on early operations which are following by heat treatment and a number of further machining operations, by the time the shortage is discovered in the fitting shop the position in the machine shop has become really serious and a long time elapses before the normal position is restored and we have a surplus of parts other than the one we are considering.

A further great use to which this machine load analysis can be put is that of ascertaining what additional men are required to meet extra output, as a complete statement can be compiled in a few hours by dividing the grand total of turning, milling, drilling, and grinding operations by 47, i.e. a full working week. You then immediately get the number of turners, drillers, etc., required, and by working backwards from the assembly section to the time taken to produce the parts, the extra labour can be recruited to synchronise with the time the finished product is being assembled. It, of course,

also works the reverse way, as when it is necessary to reduce output, instead of calling the foremen together and asking each how many men they can dispense with, the machine load is again analysed and the requisite number of men can be laid off without any fear that either too many have been dispensed with or too many retained.

I think, therefore, you will see that the knowledge of the machine load is of extreme value, both in increasing production and also in times of depression, as it definitely shows the limit of output by which the various sections are governed under the conditions of either single, double, or treble shifting. It has a further advantage of definitely ascertaining when it is necessary to buy finished parts outside, as it exposes the total inability of the machine load to yield what is required.

One other purpose to which we apply the machine load is in the consideration of the purchase of new plant, as it enables a definite analysis of the time taken to produce parts with present plant for a comparison with the times in which the same parts can be produced with more modern machines, thus enabling an economic examination to be made to ascertain whether the new capital investment can be recovered by the time thus saved.

It would have been so easy, at this stage, to have attempted to describe all the intricacies of production management technique, or the characteristics which should be encouraged when training men for future posts of responsibility in this particular field. In any case, in attempting to express an opinion regarding the method by which factories or the technical colleges can best help to prepare men for posts in factories under this new system of production organisation, I am afraid I have been forestalled as, speaking as a factory official who is ever on the lookout for useful men, who are equipped to accept responsibility, and also as one who has been privileged to help in the preparation of such men at one of the technical colleges under the Middlesex Education Committee, as well as our own works apprentices and students, I feel that if all the subjects under the syllabus of workshop organisation and management, issued by the Institution of Production Engineers, and the Institution of Mechanical Engineers, are sufficiently exploited in the works classes and colleges, and lectured upon by men who have proper qualifications, students will enter factory life equipped with far greater advantages than did men of my own generation.

One of the greatest disadvantages to-day is that a young fellow comes into a production organisation and is placed in, say, the rate-fixing department, does his job well and probably remains there for many years, and consequently has not the slightest conception as to how the estimator, cost clerk, or anyone else does his job, or for what ultimate purpose it serves upon completion, whereas a syllabus such as that mentioned, if studied by men of normal

intelligence, equips them with more than a passing knowledge of the ultimate purposes of the duties of each department.

It is amazing but nevertheless a fact that many quite intelligent young fellows in factories to-day do not know how the factory is run, or who is responsible for the various duties which have to be supervised. I myself, during the last winter session, was asked by four of the twenty-two students I helped to train at the technical college whether I could get an organisation chart from the factory where *they* were employed, as they did not know who was responsible for the various duties I had attempted to enlarge upon. These four men were of mature age, holding positions of semi-responsibility. I also was asked last winter by the chairman of a large company in the heart of London to read a paper on this subject, and the attention and enthusiasm of the staff who attended were a delight to observe. I only mention this in passing, because modern production organisation definitely separates duties and responsiblity in a manner similar to that indicated on the two plans mentioned previously, but it is very rarely that the duties of the departments are clearly defined, and even the officers in charge of them are often in doubt regarding the line of demarcation.

I cannot conclude this paper without again acknowledging my indebtedness to Mr. Groocock for using his description of the " Birth of Production Engineering " also to Mr. Healy, the manager of the Gramophone Co., Hayes, for his definition of the " Subdivision of Responsibility " and " Evaluation of Organisation Personnel " and to the chairman and managing director of the Associated Equipment Co. Ltd. for permission to construct and present this paper.

Discussion, Birmingham Section.

MR. F. ALLEN : I should like to thank Mr. Still for a most interesting lecture. For those of us who are engaged in production it has been very interesting indeed. I feel lectures of this sort on systems and organisations are very difficult to criticise because I find that the difficulties and problems one comes up against are not caused so much by wrong systems or organisations, but mostly by some person or persons not carrying out the systems laid down, or alternatively that some abnormal situation arises that no system on earth could cope with. We had some interesting facts at the beginning of the lecture, and I noticed that only one per cent. of the firms in this country employ more than 500 people. We were also given a lot of details in the lecture about the functions of the production control department. I would suggest that the production control department as outlined by the lecturer to-night would never be economical except in one per cent. of our factories, that is, in our largest factories. I am quite sure that in our smaller factories, that is the 99 per cent., such a department as Mr. Still has outlined would not be economic. I am sure there would be a great deal of overlapping. The functions could be very easily taken over by the works superintendent. I should be interested to know if Mr. Still agrees with me.

In larger factories, of course, the production control department is absolutely necessary, but I do not think it can be too strongly emphasised that the factory's production control department, with its statistical control, its clerical systems, and what Mr. Still called its works currency, must be thoroughly understood, relied upon, and worked to by the foremen in the shop. If this is not done, I am afraid it will lead to quite as much overlapping as it would do in the smaller factories. On that point I would like to ask the lecturer a question. In the working of this system the production control department has to give instructions as to types and quantities to the foremen. Do these instructions go direct to the foremen, or do they go through the shop superintendent? In the latter case I should imagine it would be very cumbersome. If they do not, I do not quite see that the shop superintendent can be responsible for the product he is supposed to supervise.

I am sure that any system which would ensure our getting in supplies from outside sources just as we wanted them, and which never allowed any surplus stock, would be an ideal one, and I think Mr. Still has indicated the right lines in advocating that the production control man should urge supplies direct from the suppliers.

There is one objection there, and I should be interested to hear what Mr. Still has to say about it. In the case of a supplier who delays delivery, I think the buyer, if he is dealing with urging, has much more influence with suppliers than the man in the works. He always has the thread up his sleeve of cancelling the order. From that point of view he is a much more useful man to ensure getting the material in the required time.

MR. F. PEARSON: I wish to ask one or two questions, and also to make a small contribution to what I consider to be one of the best moves this Institution has yet made, namely, to try and remove this technique of management from an art to a science. I am not at all clear how the works manager comes into relation to employment. Did I understand the lecturer to say that in his organisation, for instance, the employment department was under the control of the works manager, and if so, does the lecturer regard it as a functional type of organisation? I did not notice any mention of the cost department. Do I understand this comes under the authority of control accounting? If it does, how do we link up what many of us understand to be works cost department?

Another point I should like to ask the lecturer about, and which leads me on to my contribution, is the question of loading of machines. What did occur to me (and I have no doubt the lecturer had not lost sight of it) was the question of the most variable factor we know of in organisation to-day—that is the human one. How does he suggest controlling that? While we may have our rate fixers and demonstrators, we still have that variable factor in dealing with men on the job. What steps can be taken to see that the man is kept efficient?

This leads me to follow up with my own small contribution, which Mr. Still may think wise or unwise to include on future occasions when making recommendations on this very important matter. Incidentally, I have had one or two opportunities of putting these suggestions into practice, and have found them to meet with a fair amount of enthusiasm.

I assume that many of us here to-night, employed probably in the capacity of foremen, shop superintendents, or production managers, ask ourselves the question "Just how do I fit in this organisation?" It is a question of psychological control, and it is one aspect of management technique. I think if we could discuss it in terms of tools, it might help us to see the points. What psychological tools do we use in trying to get what we want to get? Thinking more of the foreman, for instance, does he have that set of psychological tools which enables him to get his men where he wants to get them? Such tools as stabilising tools, and so on. I would suggest that members might write to the section Secretary and put down on paper what they consider are some points on this interesting

question. I can see, of course, that the lecturer had not time to deal with the human side, though he had not lost sight of it.

MR. STILL: With regard to Mr. F. Allen's point that "I rather seem to have spoken about the one per cent. of factories" that criticism is perfectly justified, but I have attempted rather to speak of "duties which have to be covered" than of "people who have to cover them." As we come down the scale to smaller ones, some of these departments would be one man—are one man—and very excellent men they are. Lower still several departments may be controlled by one man, so that please do not take me too literally, and consider that *all* the people I have enumerated are necessary to run a factory. I do, however, consider that the duties may be segregated, although they may be controlled by one man.

In regard to getting people to work to systems, that is true in every walk of life. A system must have a certain amount of elasticity or it is useless, and it needs a little tenacity or pugnacity to push it through.

The finest possible method of getting everyone to work to it is to show, by the first little pieces of it that you introduce, that it is going to achieve something, and it is then just a matter of time and diplomacy, as well as tenacity, before the recalcitrant members come into line. I myself have not found any very great difficulty, after the first twelve months, in working such a system. As a foreigner introduced into a strange land, I found it difficult at first, but not impossibly so.

In regard to production control not being justified except in very big factories, I cannot say I quite agree. Perhaps the department may not be as big, nor a separate entity, but it does not alter my own conviction that the duties I tried to enumerate could still be segregated, even if in a much smaller way.

With regard to urging outside supplies, it is a good point, and unless one has had experience of actually carrying out these functions of dealing with suppliers, it is difficult to exert authority. The thought does occur to one, that one may be weakening the purchasing agent's hand.

The last question Mr. Allen raised was "Are all instructions transmitted direct to the shop?" Yes, and no. They are made out direct to each of the shop officials, but they are sent to the production superintendent, who in turn distributes them, with the necessary action to be taken as interpreted by him from those instructions. The chasers work the whole time with the foremen. They are the people who say which work is to go up, and tell the transport workers where to take it to next. The foreman follows the instructions the chaser gives him. He in turn gets his information from the machine loading section, so he knows in advance what is going to be done. The chaser never interferes with discipline by giving

direct orders to the men on the section, but transmits them through the charge-hand or foreman.

With regard to Mr. Pearson's points, I hope I have got them clearly. The first question was " Does the recruitment of labour fall to the works manager ? " Yes. Suppose we want 50 general bar turners, ten the first week, a further ten the next week, and so on, commencing September 1st. At the same time we arrange for material to come in to synchronise. The labour bureau is under the direct control of the works manager, and they advertise or recruit by whatever means they desire. The men or boys come to the works and are interviewed for selection by labour department manager and then the foreman who is ultimately going to employ them. He has the last word. Concerning machine loading, I do not know what more I can say about that. I have told you how it is used and how it is arrived at. The difficulty there, of course, is where you get an urgent demand for spares, and special sales call for special parts, but there again the value of machine loading is very great. Supposing a motor works gets a cable from Australia asking them to supply certain parts not in stock, they must supply them without holding up ordinary production, but if they go blindly into the machine shop and arrange for these parts to be made, they do not know whether they are losing ten or a hundred hours machining time. Using a machine loading chart one does know. If there are loading marks running up to the top of the chart on certain machines, then one must make up one's mind to adopt an alternative method.

In regard to psychology, I am afraid I cannot help you the least bit. I know of nowhere but in the school of bitter hard experience where it can be attained. I think the best answer is that the best training we can have for getting the confidence of those men we control is to try and govern ourselves, and when we have done that the rest will follow very easily.

Mr. R. H. Youngash : I feel great diffidence in saying anything on this particular subject, because I read the leaflet which the Institution sent out, and which distinctly states that production management technique is an art and not a science. Art, of course, always consists of wonderful flowing curves, and as an engineer I dislike flowing curves. Straight lines and round holes, yes, but not wonderful curves. Another reason why I feel some diffidence in saying anything to-night is that it is very difficult for me to criticise a paper such as we have had from Mr. Still. A man who has so largely been responsible for the evolution of the system he has described, and who can come forward and so ably present it to this section of the Institution is, beyond question, a master of his particular line of business. I do, however, see one or two difficulties, and one of them is this. A lot of trouble is caused by multi-

plicity of titles. Supposing we talk in terms of managers. We have general managers, works managers, managing directors, production managers, employment managers, and sales managers. If we call these production men, then they become production managers. We should be very careful not to be confused by terms, because, so far as I am able to discover, the problems of the small shop and the large shop are exactly the same. Mr. Still has already told us that in the small shop many of the functions will be put under the control of one man, where in the large shop there will be one man with a host of assistants, and if that is true, then it may be possible to formulate some fundamentals which will cover the whole of this subject.

There is also the danger that we are inclined to think of production technique in terms of plant only. Mr. Still has very clearly reminded us to-night that there are many other factors equally important. Proper planning of the capacities of machine tools obviously is a big factor. An adequate supply of materials at the proper time is equally important. We are liable to consider production technique as being much more closely associated with machine capacity than we are with the supply of materials at the proper time. That leads me to express this opinion, that whatever system one follows it must always be modified in some direction or another to suit existing conditions. Then we can clearly see that the production manager in the big factory will concern himself with major problems, but in the small factories will be concerned with major and minor problems. He will have to be his own employment manager, his own production manager, his own ratefixer, and tool room superintendent. Mr. Still has already told us that, and if we carefully keep that point in mind we shall avoid the danger of imagining the production engineer to be something different or new. So I am going to suggest for your consideration this evening that production technique is a proper sub-division of the personnel needed to ensure the required output of a particular works, and to my way of thinking that sums up the problem very briefly and at the same time concisely.

MR. E. T. COOKE: Speaking as a man who has spent some years in control of factories employing numbers of about three hundred or so, I am very much struck with the fact that the organisation which the lecturer has laid down is almost precisely what we have been trying to work to for a number of years. I have got some very good ideas to guide me from what he has said to-night, which I think are applicable to a small factory. I should be interested to know how the organisation he is referring to actually controls the rates paid to operators.

MR. STILL: Replying to the question as to who controls the rates of pay, actually the rates of pay with all federated firms are controlled by agreement with the Employers' Federation. The question

as to whether operations shall be performed by skilled, semi-skilled, or unskilled labour is the function of the rate-fixing department who receive the blue-print whilst the material is being ordered. The complete lay out is built up from the blue-print, and not from the actual part. They also state the grade of labour. In my own firm we only employ skilled labour, but the system has been employed elsewhere, with girl and boy labour, as well as skilled and semi-skilled, which all appeared on the lay-out card. It all depends on the system of bonus payment. Most firms, even the smallest, have some system of incentive such as bonus or piecework. In the case I am speaking of, we give dead floor-to-floor time from the blue print, and there is an allowance made in arriving at the bonus rate which includes jigging and tooling, waiting, etc., which is included in maintenance estimate. If you get a hundred hours loading with a group of operators and they take ninety hours, they have earned a certain percentage bonus. If they take a hundred and ten hours they can still earn a certain percentage bonus, but not so much as previously. The real basic rate is, as I say, governed by the agreement with the Employers' Federation.

MR. JACKSON: I have been very interested in Mr. Still's remarks. When I first attempted to introduce a system of machine loading, and discussed it with the general manager, he said to me—"There are lies, damn lies—and statistics." He was frightened of the expense. That is a big snag in trying to put that system over. People say: "Look what it is going to cost. Look what running about it is going to take!" But once you try it, you never want to lose it. With regard to the functions of the estimating department, I know that in certain industries it is customary to state what has got to be manufactured at a certain price. That does not hold good in a large percentage of factories, where there is strict competition. I should like to know the lecturer's ideas as to where the estimating department should function?

MR. STILL: In regard to the expense, and how terrible this thing looks, if you notice, I broke off in a couple of asides to explain that to you, in order to relieve your anxiety. I can only tell you that we cost less for staff in the department than ever we did before this system was put in—considerably less. Also, there are rarely any panic measures to be resorted to. We cannot prevent changes in design, with a progressive firm, but the cost of doing all panic work necessary is considerably less than ever it was before the system was put into vogue. There must, of course, be a certain amount of business in hand, or prospect, before anyone can embark on such a system. It cost £400 to compile. The machine loading book which we refer to as the "bible" and treat with almost the same reverence involved fifteen thousand entries, and then there is the cost of maintaining it, but it is worth while in the long run. With

regard to estimating, I am sorry I did not touch on that. A copy of the operation layout I have just instanced is sent to the works accountants department. The works accountants department are directly responsible for costing and estimating. They use the layout for calculating actual labour charges, and add a certain percentage for non-productive costs. They set the selling price. They do the costing. Actually, our only function from the productive side in regard to estimating is to give to the estimating department the actual machine or fitting shop time allowances that will be allowed to the shop for fabrication.

MR. J. A. FRANCE: With regard to the compilation of the machine burden chart, what actual time in the rate fixing is used to compile that chart? Do you not make an allowance for fatigue on the floor-to-floor time, and arrive at the machine burden time that way?

MR. STILL: I did not go with more elaboration into ratefixing because the paper is not on planning and ratefixing. The Institution have already had a series of papers on that subject. My idea was more to get up on the bridge and take a broad view to see how this thing had to be done. The answer to your question would take a long talk. We give actual floor-to-floor time for doing every operation on the job. We have a system of target investigation slips. Should the time be found to be insufficient for the job, the ratefixer has got to go out to the job and stop-watch it. We have no demonstrators. We let shops committee representatives and foremen on each section decide which is the man to do the trial job. Every possible movement needed to convert the raw material into the finished part is taken care of. Floor-to-floor time includes everything that is needed to convert the raw material into the finished part, but there are allowances given for extraneous work before the final bonus figure earned is arrived at.

MR. BLACKMORE: The lecturer spoke of asking the employment department to supply him with 50 men, ten men beginning one week, ten the next, and so on. Where the operations are very skilled operations, do they make any provision for training these men? One cannot always draw in men to do work immediately. It is often necessary to train men to do special work.

MR. STILL: Yes, we do make that provision. We assume new men will be of no use to us for a fortnight.

MR. W. G. GROOCOCK: Before proposing a vote of thanks to Mr. Still, I should first of all like to thank him for his very kind reference to any work I have done previously for the Institution. My own view of this series of lectures was clearly stated in the memorandum issued by the Council, and I think Mr. Still has definitely followed that line of argument. He has attempted to explain certain of the first principles which we must get hold of

if we are to turn what I still think is an art into a science. When it becomes a science we shall be able to take the technique of the ten thousand-man shop, and apply the same methods to the twenty-five-man shop. I think we can now, but we have got to get hold of the underlying principles, and some of these principles Mr. Still has mentioned to-night. I will only take note of three. Many of them he did not specifically point to, yet he was going over them all the time.

First, material control. This is essential. That is the first principle in my estimation of what should come under production management. It does not matter what the production manager is, whether the works manager is over him or under him. They all come under the same general rule, right from the managing director himself. They are all concerned with production in some little degree. The trouble is that usually the managing director thinks he is concerned with it very much more than he really is.

The second principle was machine loads. I should like to make a slight deviation from that. I should say factory load. I say that because, at the present moment, the direct labour of my machine section of my factory is 25 per cent. of the whole, and consequently the machine part is not the important part of it. That will be so in a factory producing beer or food. It is the factory load we must consider, so that the second principle I am referring to is—we must have accurate and full knowledge of the factory load. That is a fundamental.

Third, Mr. Still referred to the fact only incidentally, and yet it is a principle, that in his teaching he found it a very rare thing for students to know something of the works in which they were working. I am afraid that is quite true. They have little knowledge of what is going on. It won't be explained in the factory, but if they have responded to the teaching they have had at the classes, then they definitely will be able to appreciate what is being done in their own factories.

There, I think, are three of the fundamentals that the Council had in mind in arranging this series of lectures. I think Mr. Still has done a work which will be very much appreciated later on when it gets into print and we all have time to study it. On behalf of the Birmingham Section I thank him very much for what he has done for us to-night.

Discussion, London Section.

MR. J. G. LEGG : I will leave to abler voices than mine the task of congratulating Mr. Still on a very interesting and carefully thought out paper. My task is the more uncongenial one of endeavouring to find fault with it, and since in an impulsive moment I agreed to open this discussion it has occurred to me that there could be no task less congenial to an Irishman than to quarrel with the products of a Still.

The subject-matter of this lecture is to a large extent not a matter of fact but of opinion, and as such it is controversial. So far as any remarks which I may offer are concerned they will centre solely round Mr. Still's organisation charts because I entirely agree with him that those are the fundamentals of production management ; and that whatever the clerical system may be, that may fall down due to initial errors in organisation.

You can divide my points into perhaps half a dozen. The first of these is titles. I can only hope that there are some other works managers present who will join me in expressing dissent, and refuse to commit suicide by hanging themselves on Mr. Still's organisation tree. The question of name is perhaps superficial—but not entirely. I suppose a works manager called " production manager " would not be of any less evil odour, but the matter goes somewhat deeper than that. My idea of titles is that a title should indicate not only the degree of responsibility of its bearer but also the sphere of action in which he operates. If that is admitted I cannot see how Mr. Still justifies the title of Production Manager. It surely in itself indicates that he is solely concerned with production, and as such he is not justified in having under him such officials as the Clerk of Works, who is responsible to him through that unfortunate official the Works Manager. I think that if you gave the Production Manager on Mr. Still's plan No. 1 the title of Works Manager you would much more clearly define what is not only his sphere of authority, which is clearly indicated by the word Manager, but also the fact that he controls all the activities in the works. On the same point of titles, I cannot see how Mr. Still can justify those shown on Plan 2. He has there a Manager of Works responsible to another Manager of Production ; two Superintendents, who rank equal to a Manager, and also he has a Jig and Tool Superintendent on a lower plane than the other Superintendents and the Machine Shop Superintendent who is responsible to another Superintendent, the Superintendent of Production. I hope I have made my point.

The second point concerns the allocation of personnel. If you will

look at Mr. Still's plan No. 2 you will find that one official, the Superintendent of Production, I believe, has got two subordinates responsible to him. The Works Manager (with whom naturally I have more sympathy) has got twelve. I suggest not only that the Superintendent of Production is grossly under-worked but that possibly the Works Manager is over-worked.

The third point is what I might call redundant control. In Mr. Still's lecture he referred to the duties of a Superintendent of Production and said he was there to see that discipline was kept—frankly I don't know what else. As I see it, in a modern factory the production foremen have got their jigs designed for them by the Jig and Tool Drawing Office and made for them by the tool-room; they have their plant kept in order for them by the Plant Engineer (or some equivalent title); they have their work trucked backwards and forwards to them by some transport department—and, in effect, in a fairly well organised factory the production foreman should have the simplest job in the works to-day. He is, as Mr. Still said, primarily a disciplinarian. If he is, I suggest that the appointment of a Superintendent of Production is a redundancy. Eventually we may arrive at the desideratum that Dr. Taylor foreshadowed some forty-five years ago and do away with the bunch of so-called Production Foremen and have a Works Disciplinarian. That perhaps is a little bit ahead.

My fourth point centres in the front line battle area in which a good many battles have been fought—the Purchase Department. I know that this perhaps is the most controversial matter you could touch on. I have seen (if I may interject a personal note) three forms of control of material function all with reasonable success. One was when the Purchasing Department was directly under the control of the Works Manager; the second was the form of control which Mr. Still advocates; the third was the form of control which I prefer myself, and that is that the urging shall be done by the Purchase Department. Mr. Still's plan to me has a very basic weakness. If the urging is done by the works it does indicate that the works must have direct contact with the supply. I deprecate that because I think that any such direct contact leads to two evils—one that the poor unfortunate supplier has tried to serve two masters (the Production Department on the one hand and the Purchase Department on the other), and secondly that I do not think any action which in any way minimises the authority of the Purchase Department with the supplier is advisable. Mr. Still in this paper has put up several arguments as to why this form of control will not function. Perhaps I should say at this stage that he (and I agree) has discarded any idea of Works Management controlling the Pur-

chase Department. I think he is quite right and that it merely means that it is inadvisable for Works Management to have unfettered control of finances. I expect that is the basic reason why he would not suggest it; but let us examine the reasons that he puts forward against the form of control which I advocate. First he says that there is a duplication of delivery dates from the Works to the Purchase Department, from the Purchase Department to the supplier. Well, I think in the ordinary way the Purchase Department are bound to issue an official order to the supplier. That official order should quote the delivery date. They are bound to get that delivery date from the works. Where is the duplication? My suggestion is that the Works should dictate to the Purchase Department the amount of material which it shall buy, the delivery date, and when it must be in the works, and that is entirely up to the Purchase Department to urge that material, deliver it to the Works in time, and be responsible (as Mr. Still's chart No. 1 indicates) direct to the Managing Director for any defection.

The second argument which he advances against it is that the Works know better than the Purchase Department how long it takes to supply material—I am sure they do. But surely that is not quite a matter of opinion: it is a matter of fact. You have only got to collate your facts over a fairly longish period, and the information which those facts convey is as readily recordable in the Purchase Department as anywhere else.

The third objection to it is that in certain cases the Works possess (as instanced, the cylinder blocks) specialised knowledge which is not in the hands of the Purchase Department. That is quite true, but frankly I cannot see that it affects the point: it merely means that you have in process so many more cylinder blocks. Your period between delivery and delivery, given that larger amount of work in process, is exactly the same.

The fifth point is concerned with Mr. Still's statement, and I am quoting it. "There are few principles which can be successfully advocated or applied to both classes of factory with anything approaching equal success." It is true that we do not require the specialist organisation in the small works of twenty hands that we do in the works of 1,000, but I submit to you that the qualities that are necessary for the chief executives on Mr. Still's plan No. 1 are also necessary for the one man who probably controls the work of those twenty, though in a less specialised degree. The main requirements are there. The specialisation is not there. And surely in any factory or works approaching equal size, or in anything approaching equal type, the organisation should be practically identical. I suggest that it should, and I suggest that the Institution of Production

Engineers, who are so keen on standardisation in every other way, might do worse than attempt to give their weight to the standardisation of organisation.

The last points I have I am again quoting. The first is: "The evaluation of the capacity of each individual in the production management personnel . . . . . is the fundamental of successful management." I am entirely in agreement with Mr. Still about this and I am sure he is in agreement with me that the principle applies also to managing directors, foremen, and Prime Ministers. If you pick the men right you are all right, and the true test of a manager is the management he makes.

The other point to be quoted is "Provision has to be made for the organisation to be built round the individual and not the individual accommodated to a set scheme." Heartily as I am in agreement with Mr. Still's first quotation I am heartily in disagreement on the second one. The qualities that are necessary for a super excellent jig and tool designer are just as different from those for a super excellent buyer as are the qualifications for a super excellent machine tool superintendent and the high-grade process man. Each individual has specialised in his own way. There is only one other reason that I can conceive of (other than opportunism) for combining functions once you have laid down what those specialised functions shall be, and that is the size of the works. If you reduce the size of the works you obviously have to reduce your functions. In that case you either find one individual who combines in himself in a less specialised degree all the qualifications necessary for your five major functions, or else if he combines those in a less degree he possesses the other quality which Mr. Still wisely stresses—the ability to make other individuals do the job for him.

If I were a bookmaker (which perhaps unfortunately for my family I am not) I would not lay any odds against any man possessing two sets of the specialised functions that are necessary either on Mr. Still's plan No. 1, his plan No. 2, or on any well-organised scheme of organisation. I think the nett result of this combination of duties would be one of two things—you would either have an immense difficulty subsequently in filling the amalgamated duties, because you must have had an exceptional man to do it originally, or else you would revert back to the truly specialised form of organisation.

MR. STILL: Just to reply as briefly as I can to the points Mr. Legg has mentioned, I would like to relieve any feeling from the minds of any members or visitors that there is no attempt to deprecate the position of the works manager as such. It should not be thought that that is intended at all, but rather to segregate the two

duties, that of managing the works and that of being directly and definitely responsible for the production of the product. I owe far too much to the training received from works managers in the past.

Mr. Legg has taken exception to the titles. I am going to dismiss that very briefly. The titles have to be superimposed to cover the duties and they are intended really to cover the duties more than the actual title. Surely the general manager of the sales, for instance, must manage the sales in general: surely the only name for the manager of the service department is the service manager: home market home sales manager: the one who travels, overseas sales manager, etc. He mentioned also the question of the production superintendent. Surely that must cover the machine shop superintendent. You could not give him a different title from that: he is in charge of all the foremen in all the various lines, but I think the answer briefly is that the titles are not so indicative of the sphere of action as the duties they cover.

The extent of units controlled. Mr. Legg has already told you what wonderful men the works managers are, and it is only right that they should have twenty times as much work as the others. I agree that the works manager on the group of duties I have shown you has the largest group of duties, and that is as it should be. He has the whole of the chemical laboratory under his control: he has the whole of the viewing under his control, so that he has no bias by production, He is there to see that the standard is adhered to as laid down by the management, and all the other very important duties which he, with his profound knowledge, is the only man to carry out.

Mr. Legg says the superintendent of production is probably redundant—the foremen don't seem to have anything to do. In the ideal firm the production superintendent and all the foremen should come in a white coat on Monday morning and should go home in it spotless in the evening. They should have no work to do. They should go home as clean on Saturday as they come on Monday. That is production management as it should be. That is what we are trying to do. I quite agree that if you are going to measure responsibility the post is redundant but not quite. We do not undertake the supervision of direct labour. We think it unwise, so that in brief the production superintendent is responsible for direct labour. We have no say in it at all. I think I mentioned to you that the chasers who have the giving out of the work on the section and have to arrange for the material to be there, do not transmit instructions to the workmen, they transmit them to the foreman or the charge-hand. It is entirely an unofficial matter.

The Purchasing Department. I thought I had said sufficient on that to show my point of view. I can only say emphatically,

No! No! No! The question about weakening the purchasing agent's hand is an entirely erroneous idea. I can say that the purchasing agent and myself are the two finest colleagues in the offices of the company I serve; there is never any feeling of friction between the two departments, and in fact no one could wish for a more helpful colleague. The point of working for two masters is not true. The purchasing agent naturally gives the actual order: he has no say in the commercial transactions; they come direct under the one department. We deal with firms throughout the British Isles, coping with 38,000 part numbers. There is no friction: we do make personal contact. We have men in each area who visit the firms, and we find that where the purchasing agent used to pass us a chit saying "Delivery next Wednesday," on Tuesday they have not even got the steel. We do things that you could not do if you were transmitting this information through a third party. So anything I may say to amplify a reply to Mr. Legg would merely be a repetition of what I have included in the paper.

The main principles applicable to small factories. I quite agree that when production management has become a science and not an art it will be possible to apply in broad principles the same line of action as would take place in the thousand-odd factory to the smaller place. Actually there are many small very excellently conducted factories up and down the kingdom that do apply it.

The last point was the organisation built round the individual. I was obviously laying myself open for sniping there. I think that in general the scheme should be framed, but you will always have to cater for individuals, especially in a firm that values goodwill and long service. In these changing conditions in which we are living in this decade, where these duties are having to be segregated, if you accept for instance the different points I have mentioned to-night and you decide to put it in your own factory to-morrow, you would be fortunate if you found 60 per cent. of your staff who could be adapted. What are you going to do with the rest? Are you going to kick them out? If the scheme is not sufficiently elastic to cater for individuals where there are men with ability and integrity but not necessarily adaptable to the particular scheme you have got, are you going to employ the American Dr. Taylor methods and discard them? I do not agree with that at all. In some cases you must have a system which shall adapt itself to individuals and not rigidly a system which must be adhered to by individuals.

MR. W. MOSEY: I would like to support Mr. Legg. I have had the opportunity of seeing factories of all sizes. There is no doubt that in order to work a factory satisfactorily you must have a chart;

you have got to try to put people in their places, and if they don't quite fit into their places try to educate them into their places if you cannot replace them. If you do not do that you will so often burn your fingers due to people over-lapping ; but really the organisation becomes an impossible one to work. I have seen so many factories now that without question of any sort anyone who attempts to adapt too far his personnel to his conditions will come into a great deal of trouble.

The next point I want to make is that I would like to defend the position of the Works Manager : I think he still does exist. Whether you call him Works Manager, or perhaps as Works Manager in both capacities, he is still there. Someone must organise the production people, must organise all the various offices connected with the building of the works or extending. There must be some person to whom everybody must refer. If you have a production man who is primarily and wholly lop-sided on the score of balancing his plant and his labour, if you are going to refer the question of, say, drains to him you are not going to get the same attention that perhaps the drains warranted.

MR. STILL : You have really a repetition of the same two questions as before, except that the last is first and in this case our friend mentions that you will have trouble if you try to adapt a factory to the individuals and not to the system. I agree all along. I say that I have too much faith in human nature and I have too much loyalty towards men who try to serve a company. It has got to be gradual, and he will at least for some of the time have to suit individuals in some cases and not a rigid system. With regard to the Works Manager, we seem to get right on to that point, but if you come to look at the group in that first chart, the welfare of the whole of the factory is definitely that of the Managing Director who presides at the weekly conference over those principal officers. The degree of responsibility descends through the lines of functional management, and the answer is there on that sheet the whole time. The Works Manager is not as ten or twenty years ago the man who can walk about, sack the chief accountant, and do everything else he liked. The whole idea is simply and solely to descend the line of responsibility into the separate departments.

MR. N. GERARD SMITH : As everybody else in this room, I think I want to quarrel with the organisation chart and particularly with that part concerned with production control. I leave, therefore, on one side the service duties which we generally put under the works engineer. There are surely only two things to do in production —two functions—one technical and the other clerical, and when I say clerical I do not mean that in any derogatory sense. A task has to be set by somebody—presumably the Board of Directors—in the

first case; they decide what shall be done. The clerical people then have to break that down right down to the machine, and, in effect, tell the technical people what they have to produce from every item on their plant, getting their technical information from the people whom they are instructing. You can call him works manager, production manager, or whatever you like, and I am willing that they should produce the material: whether they do it direct or through an agent does not matter—but having set that task it is then up to the technical people to carry it out, and to carry it out they must have control over everybody concerned with production, and every official put into a factory is put there to co-ordinate the function of a greater number than himself—that is, the foreman co-ordinates the efforts of the men. I can imagine the biggest possible works in which you still would not have so many different functions as are put on this chart because you would have the works manager controlling perhaps six factories. To take your motor, for instance, you would have your engine works, your chassis works, body works, etc., each with its own manager in charge, but the control people and clerical people are telling every production unit throughout the place what they have to do and when they have to do it so that final assembly can be proceeded with having everything to hand. I think that is the basis of the whole matter, and it really does not matter what you call these people.

MR. STILL: Mr. Gerard Smith is on my side: he has told you another thing in another way, that the people on the clerical side tell the technical people what to do. All I have told you is that we go further than that: we are the clerical people and the technical people, and leave the performance people to do the job when we have done that for them. That is the answer to that; we merely go a stage further.

MR. B. H. DYSON: With regard to the jig and tool department. I maintain that surely if the material control should come under the Superintendent of Production Control, so also should the jigs and tools because very often these are supplied by outside suppliers and urging very often is more essential on jigs and tools than on material—at least I find it so. Therefore, as I see it, in this management chart the jigs and tools must definitely come under the production manager's control. Machine loading. Mr. Still tells us that the ratefixers calculate a time for the various operations and then these times are used for the machine-loading. I should like to know what contingency has to be allowed. I assume that when rates are set to time he makes various allowances for personal fatigue and that sort of thing, but you will all agree that there are various other contingencies, and surely these have to be taken into account before you can load up your machines.

The other question I would raise is regarding material supply: whether it should come under production or purchasing control or not, I wonder what sort of formula, method, or system Mr. Still adopts when really getting supplies. You can specify a delivery date and send your urge cards; you can get on to the phone to suppliers, you can wire them and do what you like, but in some cases you cannot get delivery. You cannot control the contingencies that other people come up against, so really who ever deals with it you come back to the same point, that it needs something more to enter into it to make this production scheme work. You have got to expect all the other firms to come into your plan or scheme of organisation, which I maintain is rather difficult.

MR. STILL: The points there are particularly good—the jigs and tools coming under the production management department. I rather anticipated some such question, and I mentioned that they can function under one head. In at least five firms where this system is practised they do, but it has been found in various firms that they are so closely knit together with the plant department in many cases that they are almost an integral part of it. That is the only reason they are separated. There is no reason why they should not be shown in the group of people under the production manager.

Urging jigs and tools. I do not quite agree there because there is such a lot of technical correspondence which requires specialised knowledge, and it would be unwise for the purchase department or any department except the jig and tool superintendent himself to conduct all that correspondence which is locked up with deliveries. In the case of small tools such as drills, that is progressed in the usual way.

With regard to loads—the system of loading must be governed by whatever system of bonus payment you have. In our own works we give definite floor-to-floor time. We have no contingencies for anything at all, but in arriving at the bonus there is an allowance given whereby all contingencies are taken care of—hard materials, personal needs, waiting for material, and things of that kind. When the time taken on a job is being assessed for bonus payment in the works accountant's department there is a bulk allowance given before the bonus is arrived at.

The last point. How do you definitely progress the material supplies. I do not know that it is possible to give you a hard and fast rule there. I can only tell you this, that when you have been dealing with a group of firms for at least four or five years you know the recalcitrant members. You know the group of people in Sheffield, for instance, upon whom you can rely and those you

cannot, and so on your monthly visit, or whatever it may be, you make a point of taking your trader's schedule for that firm with you and looking at the work in progress in the shop. These firms will welcome you in after the first month. One of the biggest firms in Sheffield four years ago when we started this system did not quite bang the door in our face, but we did not get in the works. We got in communication with the Chairman through our own Chairman, and to-day they have built a special building for the reception of progress clerks from outside firms. They have had to engage a special staff to cope with the business. On this monthly schedule you cross off the people who come up to scratch. You keep in touch with those who give a little trouble, and those whom you know you have trouble with you keep chasing them up, but the money expended is well worth the trouble.

MR. C. C. FERGUSON: Getting down to the direct labour side, Mr. Still referred in his paper to budgeting for labour four or six weeks ahead. How can that be done to-day when there is such a scarcity of skilled labour? I do not see how he can budget with any degree of accuracy on that point. The most important commodity to-day is the supply of direct labour. Mr. Still showed us a red and black chart which disclosed shifts and the number of workpeople employed on double-day shift or night and day shift—I am not certain—but there was also a reference made to the three shifts. That definitely must upset the original estimates of the price given because you have to pay an enhanced rate for the workpeople engaged. I would like to know how you get over that. Another point is that on the chart there is no reference to the estimating department. There is also a point about idle machining time, and Mr. Still referred back to extraneous duties he defined as gauging, chucking, etc. They are not extraneous—they are essential.

MR. STILL: With regard to the recruitment of labour, it does not matter whether you call it four or five weeks or days. We have experienced the same difficulty as all firms have in recruiting labour, but we have been able to engage all the skilled labour we want. It is more difficult to get material than labour. The question of estimating is one which in our own organisation we leave solely to the works accountant. He estimates from the layout with which we supply him. In the case of an inquiry only, if it is of such a character that there is no part where he has a lay-out he confers with the rate-fixing department and they agree to a layout upon which the estimate is prepared. We have nothing to do with preparation of estimates excepting that a copy of every layout we make upon which the bonus times are paid in the works is sent to the works accountant who controls the whole of the estimating. The question

of idle machines. I mentioned that it is obvious that there must always be machines like that, especially single-purpose machines.

MR. A. T. S. GROOMBRIDGE: I think you will all agree with me that this evening we have heard a very interesting paper. Many here undoubtedly will not agree with the various titles Mr. Still has given for the various principals and functions and grouping of duties, but generally I think we shall all go away with very much food for thought.